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Introducing Young Learners to Robots and Coding through the Very Hungry Caterpillar

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Abstract

Educational robots are a technology tool that can be used in classrooms with young learners to enhance students' interest, engagement, and achievement in STEM subjects. By including the reading and writing "R" and the arts "A" in STEM, teachers can develop STREAM lessons that foster foundational literacy skills through creative and playful learning experiences. This article shares research-based best practices for integrating STREAM into the instruction of young learners. A first-grade lesson that connects robots and coding with Eric Carle's (1969) children's book *The Very Hungry Caterpillar* while incorporating concepts from science, mathematics and the arts is presented. Strategies for extending and adapting the lesson through writing, journaling, and additional pieces of children's literature are also discussed.

Keywords: educational robots, interdisciplinary learning, art, reading, writing

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Employment in science, technology, engineering, and mathematics (STEM) occupations has grown 79% in the United States since the 1990s and is expected to grow by another 13% by 2027 (Funk & Parket, 2018). However, according to the National Science Foundation Human Resources Advisory Committee (2020), many Americans enter the workforce without a basic understanding of STEM facts and approaches. STEM education has become a priority of schooling systems worldwide seeking to implement STEM content into the curriculum (Pressick-Kilborn et al., 2021). For example, Greece began requiring coding education starting in 3rd grade, France in 5th grade, and Spain, Germany, and other countries have indicated that computing will become a compulsory part of the curriculum (Rich, et al., 2018). In the United States, the Computer Science for All initiative was launched in 2016 to help all K12 students to learn computer science skills so they may be equipped to participate in a digital economy and a technologically-driven world (CSforALL, 2022).

With the inclusion of arts into the STEM approach, STEAM education has emerged as a method that recognizes student creativity as an essential component of the scientific literacy of the younger generations (Aguilera, & Ortiz-Revilla, 2021). The approach has also been extended to STREAM, with a focus on connecting reading, writing, and arts with the four STEM disciplines (Subramaniam et al., 2022). Using the STREAM approach, teachers can develop lessons that teach students these foundational new literacy skills through creative and playful learning while reading children's literature and linking the story to content across the STEM subject areas. By adding reading and multimodal literacy, students can express learning outcomes of STEM content through creative writing, journaling, and poetry while capturing what is learned in their own voices.

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Educational robots are a technology tool that can be used in and out of school environments to enhance students' interest, engagement, and academic achievement in STEM subjects (Anwar et al., 2019). Such robots can take on multiple forms, from student robotics kits to fully programmed socially assistive robots used in the classroom to aid student learning (Papadopoulos et al., 2020). Coding is a set of instructions a robot can read and execute, and the skill of creating code is increasingly recognized as a new literacy that should be fostered at a young age (Monteiro et al., 2021). As creative approaches to STEM, STEAM, and STREAM continue to gain importance, educators need to know how to implement such interdisciplinary lessons into the classroom starting at the earliest grade levels. This article shares research-based best practices for integrating STREAM into the early elementary grades. A first-grade lesson that connects robots and coding with Eric Carle's (1969) children's book *The Very Hungry Caterpillar* while incorporating concepts from science, mathematics and the arts is presented. Strategies for extending and adapting the lesson through writing, journaling, and additional pieces of children's literature are also discussed.

Background and Literature

Evolution of STEM and STEAM Education

As education reform efforts continue to call for connecting learning in subject areas and ending the fragmentation of disciplinary knowledge, educators have planned and implemented integrated lessons focusing on STEM and STEAM. Some issues or themes that surround the literature include interdisciplinary teaching and learning through connections in disciplinary knowledge; innovative and ambitious instructional practice; and real-world problem solving

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through active engagement of students in a variety of learning experiences (Holmund, Lessig & Slavit, 2018). Starting with STEM education a possible definition can be considered:

> STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Nathan & Nilson, 2009, p. 3).

For STEAM education efforts, a possible definition can be considered: STEAM Education is an approach to learning that uses Science, Technology, Engineering, the Arts and Mathematics as access points for guiding student inquiry, dialogue, and critical thinking (The Institute for Arts Integration and STEAM, 2022).

> STEAM is a way to take the benefits of STEM and complete the package by integrating these principles in and through the arts. STEAM takes STEM to the next level: it allows students to connect their learning in these critical areas together with arts practices, elements, design principles, and standards to provide the whole pallet of learning at their disposal. STEAM removes limitations and replaces them with wonder, critique, inquiry, and innovation" (The Institute for Arts Integration and STEAM, 2022).

The content of the arts includes a variety of social, cultural, contemporary and historical concepts. In education, the arts are often taught by focusing on the performance or production of artistic understanding (art production and performance), the historical and contemporary influences of culture (arts history), the philosophical contemplation of why and how artworks or performances can be defined (aesthetics), and the analysis, interpretation and evaluation of

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artworks or performances (arts criticism). It is the combination of these four study areas that form the foundation of art education. For students studying the arts helps to connect concepts in a variety of disciplines and make sense of the world and themselves (Goldberg, 2016). As a form of communication and meaningful expression, the arts are valued in society for many reasons including an avenue for developing students' creative potential, for promoting critical thinking and reflection, and for innovating the future (Szekely & Bucknam, 2012). The disciplines of art history, art criticism, art production/performance and aesthetics are closely connected and are an integral part of all learning when the arts are integrated into STEM becoming the STEAM approach to curriculum (The Congressional STEAM Caucus, 2013).

The arts are best taught in a safe learning environment where students feel secure to express their ideas freely. Since creating artistic work is a reflection of students' lives, students' interests and exploration of concepts should be valued and integrated into arts learning. Through arts integration, students learn to create expressive work, consider philosophical ideas about the arts, discuss artistic work, and study historical and contemporary connections to culture. The goal of learning in and through the arts is to better understand the self, others, community, and the world (Anderson & Milbrandt, 2005). Using the STEAM approach requires educators to value all of the integrated disciplines. Curriculum that reflects the STEAM model has the potential to actively engage students in meaningful learning that impacts their lives and others with whom they interact. With the inclusion of the arts into the educational STEM approach, STEAM emerges as a method that recognizes student creativity and as an essential component of the scientific literacy of younger generations (Aguilera & Ortiz-Revilla, 2021).

Research on Robots and Coding and Young Learners

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There has been a steady growth in the number of studies examining educational robotics and their impact on young learners' social and academic skills (Anwar et al., 2019). Regarding young learners, Toh et al. (2016) systemically reviewed 27 studies that focused on the use of robots in early childhood education and found the ways robots in education aid in children's behavior and development revolved around four themes:

- Problem-solving abilities, team skills, and collaboration
- Achievement scores, science concepts, and sequencing skills
- Language skills development
- Participation

These findings highlight how using robots in education has the potential to influence young learners in the areas of cognitive, language, and social development. For example, in one of the studies reviewed Varney, et al. (2021) examined an in-school program that introduced LEGO robotics to foster young learners' interest in STEM topics. The program was adapted from a successful summer program but offered with no financial burden to third-grade classes at a Lansing, Michigan, United States elementary school with a diverse population during regular school hours. The program's effectiveness was shown through teacher testimonials, with teachers reporting students who had participated exhibited character development traits like teamwork skills, were more focused and engaged in STEM discussions, and showed a deeper understanding of certain math and science concepts. Another study that Barker and Ansorge conducted (2007) was aimed at assessing impacts on student achievement and examined an after-school science and technology program based on robotics for 9- to 11-year-olds in a Nebraska, United States, elementary school. Through the program, students used a LEGO robotics kit to

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build a "tankbot" and then ROBOLAB software to program their creations to do increasingly more complex tasks. Experts from the Carnegie Mellon University Robotics Academy developed the curriculum for 4-H, and the assessments used were based on the 4-H curriculum. The study results demonstrated that youth who participated in the program had significantly higher posttest scores, and the control group had no change in mean scores from the pretest to the posttest. Regarding robotics and language development, a robot storytelling system called GENTORO was studied by Sugimoto (2011) at an elementary school in Japan. Children can use the system to express their stories by making the robot play them in an immersive environment that integrates virtual and physical features. The results of the study indicated that the robot system enhanced children's participation and engagement in tasks and supported their design and expression in creating digital stories.

These are some of the studies focusing on how young students are using robots to enhance learning. This shows a need for pre-service teachers to be prepared to implement robots into their future classrooms. Xefteris (2021) created a course for undergraduate pre-service teachers focusing on creating a multidisciplinary curriculum with robots named "S.T.E.A.M Teaching Scenarios using Educational Robotics". Students in this course explored storytelling techniques, created stories, exploring music, history and art using a variety of different robots. More programs such as this one could make pre-service teachers more confident incorporating robots in classrooms of young students.

STREAM: Putting the "R" in STEAM

The importance of expanding the STEM and STEAM approach to include reading/writing thus becoming STREAM is supported by the benefits students gain. Storytelling

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is an effective strategy for integrating STREAM into education (Martinez & Nolte-Yupari, 2015). Expressing knowledge through different media supports students' literacy development and can be implemented through an interdisciplinary approach, STREAM.

Journaling, sometimes called freewriting, gives students the opportunity to write for themselves and capture their initial impressions about a topic. Barbieri (1995) tells her students about freewriting and explains, "words came onto the page that I had not intended; the whole point of what I had been trying to say became clear to me, and I knew what I needed to write next. Stunned, I thought I had discovered magic" (p. 16). Freewriting also encourages students to share their unique writing voices. Romano (2004) believes, "crafting voice is necessary in order to write, and for me at least, to make it more interesting" (p. 11). Students can use freewriting to write about their classroom experiences with technology and working with robots.

Teachers need to provide their students with time to discover and share their ideas. Fletcher (1993) elaborates, "helping young writers find this inner voice starts with time – giving young writers the regular time they need" (p. 72). In addition to using freewriting as a method of expressing their reactions and opinions, students may choose to write fictional stories, perhaps a sequel to the story discussed in class, or draw pictures. Rief (1992) argues, "creating is the highest form of intellectual development" (p. 149). If students write an original story, they may choose to return to the robots to act it out. Graves (1994) advises teachers, "for some writers a new topic may emerge while they are writing about another" (p. 82). Therefore, writing about an experience with the robots in the classroom may lead to an idea for a short story or a poem. Heard (1999) values connecting writing with art to develop new ideas and teaches students, "and as you draw, write your thoughts down alongside your drawing. I usually draw a little, then

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write, then draw again, then write" (p. 101). Journaling provides opportunities for students to explore thoughts and use freewriting as a starting place to implement innovative ideas.

STREAM Benefits for Young Children

The National Association for the Education of Young Children (NAEYC), the largest early childhood professional association in the United States, defines the early childhood years as being from birth through eight years and considers early childhood education an indispensable aspect in shaping dispositions, skills, and love for learning that will last a lifetime (Copple, & Bredekamp (2009). The early years are an important developmental time frame to help children develop positive connections with integrated learning approaches like STEAM. The positive learning experiences must be frequent and itself sustained with guidance commensurate with the learning needs of the child - altogether these factors lead to a greater likelihood of long-lasting benefits for children and affect their learning potential (NAEYC, 2009).

According to a cognitive development theory proposed by Piaget (1957, 1969), young children are biologically-driven to explore their environments using sensory experiences (e.g., motor, sight, sound, taste) and in developing language through reflection. As a result, children's memory systems are constructed (schema building), facilitated by gaining knowledge and direct experience. Vygotsky's cognitive theory (1986), which proposed that thoughts and language are intricately intertwined, further emphasized the importance of adult role models or other children that have more experience to act as guides. Therefore, during the early years introducing concrete and hands-on learning activities can help the child make the connection between STREAM ideas and language or thought.

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Encouraging a playful learning environment nurtures creative play and positively affects children's cognitive, physical and socio-emotional development. "Play awakens the creative energy needed for intellectual development and for healthy human development as a whole" (Nell & Drew, 2013, p. 29). Connections through STREAM create deeper comprehension and appreciation of not only the aesthetic qualities of the work but can also lead to valuing creative playful learning (Nell & Drew, 2013).

Description of the Lesson

As Monteiro et al. (2021) point out, "bringing computing into the education of young children is necessarily an effort that cuts across disciplines. Separating computing from other school subjects neglects its social and cultural branches and falls short of the goal of encouraging active and critical engagement with technology" (p. 5). The interdisciplinary STEAM approach can be used to introduce young learners to robotics and coding through lessons that integrate material across subject areas. The lesson described in this article is an example of how the use of robots and coding can be integrated with science, reading, art, and mathematics for students in the lower elementary grades. The robot used for this project was provided through a grant awarded to a Florida U.S. university faculty member to support community-engaged research with local organizations. Faculty members from the university visited the K8 school in early 2020 and observed the lesson.

The Educational Robot Used

The Dash & Dot robots are educational robots created by Wonder Workshop (Huang et al., 2019). The robots have built-in sensors such as a speed sensor and an infrared sensor, as well as sound and light effects allowing for interaction between the robot and the child (Huang et al.,

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2019). Dash is a small mobile robot, and Dot is a smaller sidekick. Children can use block coding to program the robots with an iPad app using these robots. A diagram of the Dash robot used in this lesson is shown in Figure 1.

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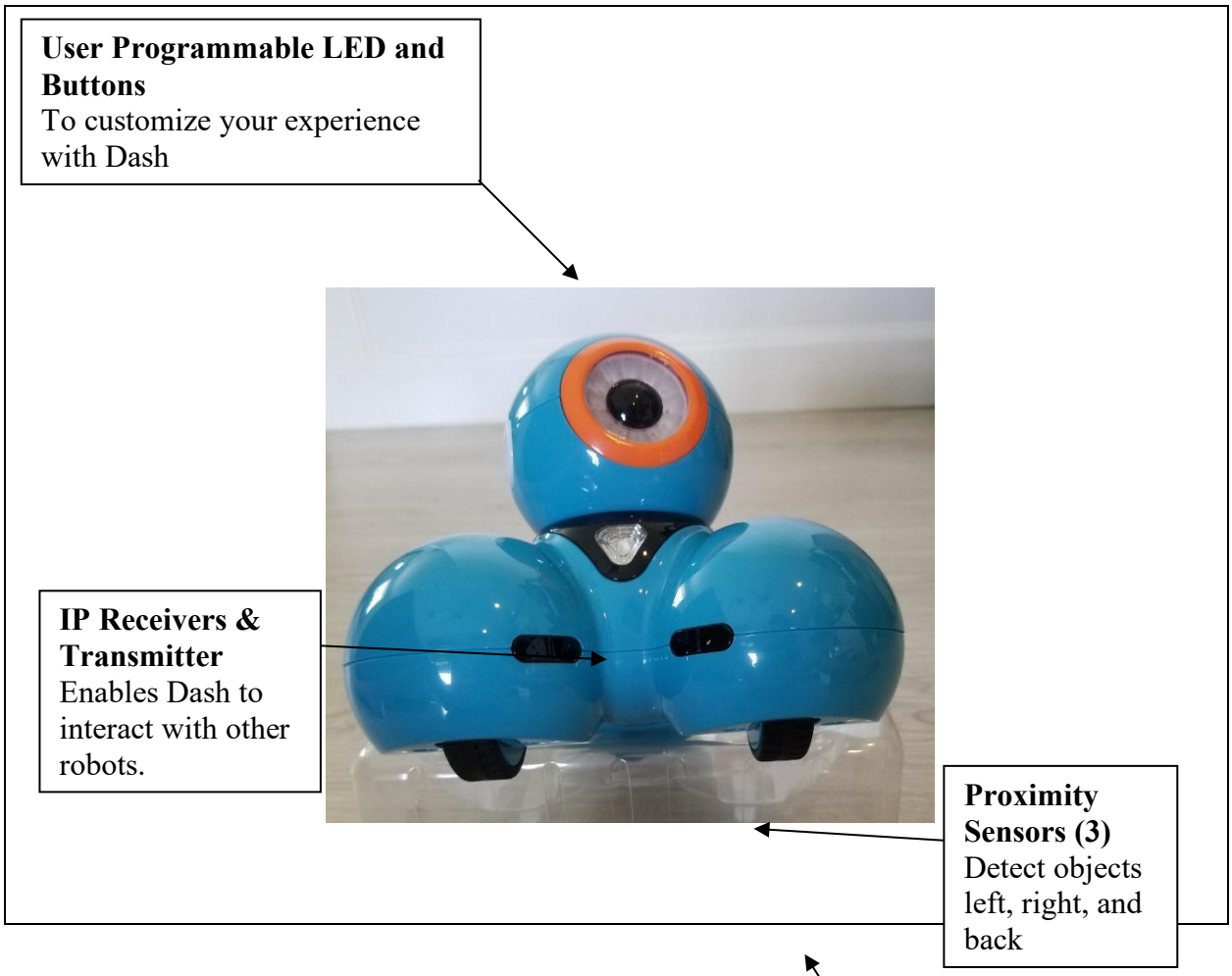
Figure 1. Dash the Robot



Note: Adapted from https://www.makewonder.com/robots/dash/

Some parts of the Dash robot that are not visible in the dia

microphones, speakers, and Bluetooth connect to IOS, Android, and Kindle mobile devices.

Lesson Implementation

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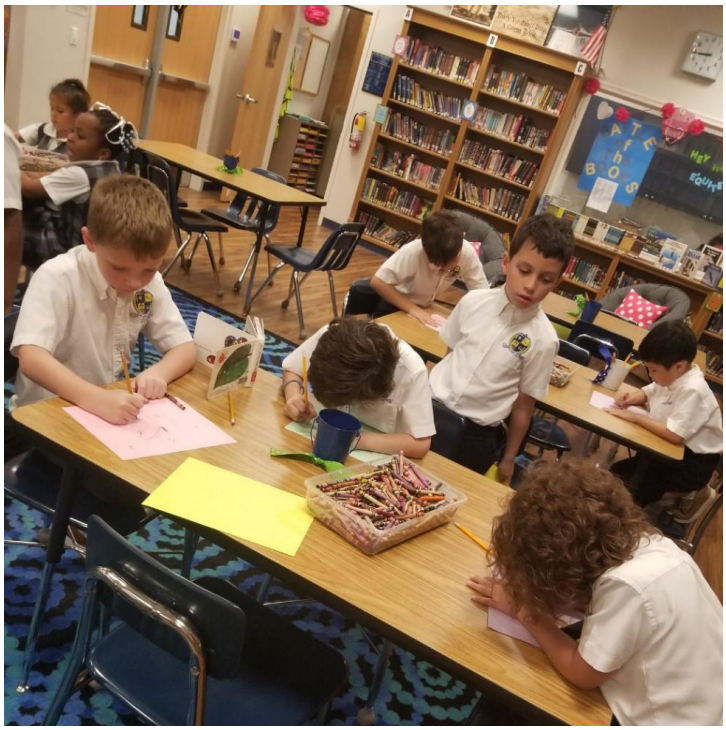
The robot used for this lesson was called Dash. The lesson took place in a media center comprised of a library and an adjacent computer lab. The lesson began with the technology teacher reading the book *The Very Hungry Caterpillar*, written and illustrated by Eric Carle in 1969, to the first-grade class of students. To reflect on the story, students were asked to recall the different stages of the hungry caterpillar's life: the egg, larva (caterpillar), pupa (chrysalis or cocoon), and adult butterfly. As each stage was identified, the teacher discussed its characteristics and reviewed pictures of them from the book. Once all four stages were identified, students were seated at four table groups (one for each stage) and equipped with drawing paper and crayons. Next, students were asked to create drawings of the life stage assigned to their table and draw a visual representation of it, as shown in Figure 2.

Figure 2. Students Drawing the Life Stages of the Caterpillar in the Story



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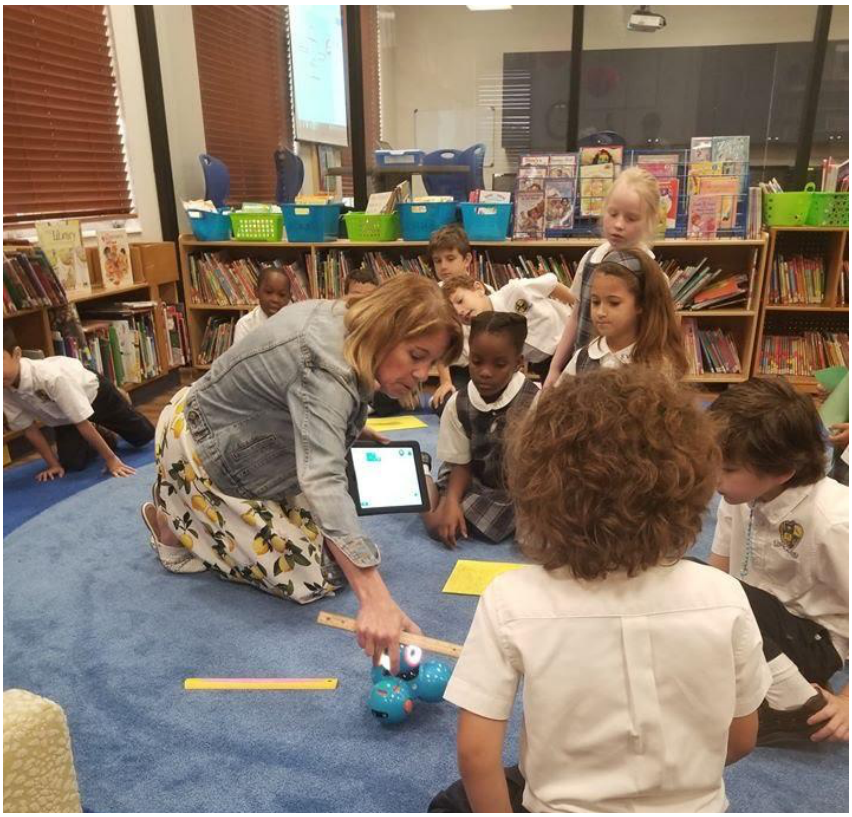
The teacher reinforced reading and science concepts through visual arts integration by asking the students to reflect on the life stage of the caterpillar in the story.

Once the students finished drawing, some of them stood up to share and describe their creations with the class. Then, the teacher collected one picture from each stage of the butterfly life cycle and directed the students to sit together in a circle on the floor on a large carpet, and introduced Dash the robot to the students. Next, she asked students to identify the first two phases of the butterfly life cycle and placed the drawings of them on the carpet. Then, the teacher asked a student to help measure the distance between the two pictures on the floor in centimeters, as shown in Figure 3.

Figure 3. Measuring the Distance Between Drawing in Centimeters



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Then, the teacher showed students how she could use block coding to program Dash to travel on the carpet from the first stage to the second. At each stage, a student volunteer recorded their voice, stating the name of that stage on the iPad. The process was repeated to program Dash to travel in a large rectangle around the carpet to all four stages and play the recording of the children saying the stage name upon arrival at each drawing.

Adapting to Other Stories

The suggested strategies were tailored to the story *The Very Hungry Caterpillar* (Carle, 1969). Children enjoy viewing brief videos of authors and illustrators at work, which provides modeling for how stories and artwork are created. Extensions or added resources for this children's book are included in Appendix A. The strategies for this example lesson can easily be adapted by teachers to other works of children's literature that involve sequencing of steps. Since students read the story and created drawings of each stage in the butterfly life cycle, which led to the programming of Dash, students could write and illustrate an adaptation of the storyline for other books. Examples of such books include:

- Bridwell, N. (1963). *Clifford the big red dog.* Scholastic.
- Carle, E. (1977). *The grouchy ladybug.* HarperCollins.
- Carle, E. (1995). *The very lonely firefly.* Random House.
- Cronin, D. & Lewin, B. (2001). *Click clack moo: cows that type.* Simon & Schuster.
- Keats, E.J. (1962). *The snowy day.* Viking.
- Martin Jr., B. & Carle, E. (1992). *Brown bear, brown bear, what do you see?* Holt.
- Numeroff, L. & Bond, F. (1985). *If you give a mouse a cookie.* HarperCollins.

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Conclusions and Future Research

Teaching and learning strategies in each discipline of the STREAM model with an emphasis on art, reading, and technology assist teachers in planning instruction. Active engagement of students in the learning process can be supported in many ways, including the STREAM approach. There are many strategies that can be utilized when integrating visual art and reading and writing with STEM through the STREAM approach. As passionately stated by McClure (2017), "early STEM exposure is critical for later educational outcomes; when adults downplay its importance in the early years, they also diminish young children's current and future potential" (p. 214). Therefore, strategies that can be implemented with young learners are especially needed.

Research indicates that robots can be used by teachers to foster young learners' interest in STEM concepts (Varney et al., 2021) . According to Cheng et al. (2018), "The current state of the art of educational robots indicate an urgent need to explore the essential applications of such robots" (p. 400). At the same time, when we integrate technology, we must always be aware of our teaching goals and use them to achieve their point by point instead of just mixing and matching various technology tools to motivate or engage students (Xefteris, 2021). The lesson described in this study used the Dash robot with first graders to retell the story of *The Very Hungry Caterpillar*, but a less costly educational robot like the Sphrio Mini could easily be used in its place. In addition to switching up the technology, educators can choose different children's stories that involve a sequence of steps to create their own unique lesson plan.

Introducing young children to robots, coding, and "deep learning" are among the game-changing technologies that are altering how people think, learn, live and work. Moreover,

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exposure to STEM topics in early childhood is critical for later educational outcomes; failing to implement it may diminish young children's current and future potential (McClure, 2017). Therefore, now is the time for educators to seriously consider how technologies on the horizon will impact teaching, learning, and the world that awaits students in the coming years. By extending the approach to STREAM teachers can provide opportunities for young learners to express learning outcomes in STEM content through creative arts, reading, and writing while developing literacy skills across disciplines. The lesson presented here offers a simple and easily replicated, and adaptable model for educators to introduce STEM content through STREAM to young learners.

Another way to extend the reach of this concept is to bring the story and the robots out into the community to engage children and families in informal STREAM activities. For example, the teacher shown in this article has subsequently taken the robot to a family event in a rural area of western Palm Beach County to replicate the lesson with a population marginalized by poverty and less access to digital technologies. Future community-based STREAM events are in the planning phases to extend this research beyond the formal classroom education setting. Future research on how informal STEM activities that link STEM concepts to children's literature may explore how these experiences help children form STEM interest, knowledge, and identities while also examining intergenerational learning processes.

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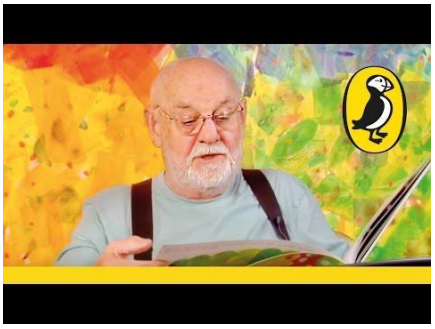
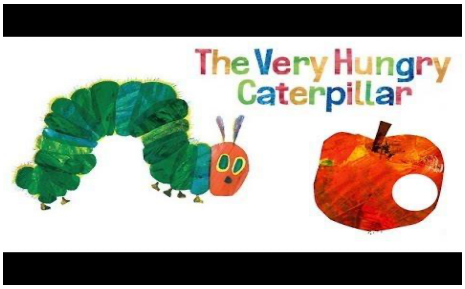
Appendix A

Technology Resources for The Very Hungry Caterpillar

Resource Type	Description	URL
Video	Eric Carle reads The Very Hungry Caterpillar	https://www.youtube.com/watch?v=vkYmvxP0AJI 
Video	The Very Hungry Caterpillar - Animated Film (not read by Eric Carle but used often by teachers)	https://www.youtube.com/watch?v=75NQK-Sm1YY 

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Video	The Very Hungry Caterpillar | Eric Carle Creates 45th Anniversary Collage	https://www.youtube.com/watch?v=OCaFkD5xrXI 
Web page	This web page has a great photo of Carle in his "Messy" studio, which can appeal to young children. It's okay to get messy when being creative.	https://www.carlemuseum.org/about/about-eric-carle/artistic-process
Web page	The life cycle of a butterfly lesson plan	https://www.education.com/lesson-plan/life-cycle-of-a-butterfly/
Worksheet	The life cycle of a butterfly worksheet	https://www.education.com/download/lesson-plan/life-cycle-of-a-butterfly/attachments/file_401792.pdf
Handout	Butterfly garden instructions	https://cdn.shopify.com/s/files/1/0075/6983/4020/files/Caterpillar_QG_2020_rev2_1.pdf?v=1586537101

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Webtools as Strategy: Online Resources to Support Academic Writing in Lower-Division STEM Courses

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Abstract

This study investigates the use of webtools to provide strategy support for student writing in lower-division STEM courses. In recent decades, writing with technology tools has become more of a part of school and life tasks. By the first years of university, students have had years of instruction and experience with writing; yet, the demands of writing also continue. For students in STEM subjects, the writing of lab reports as a new and distinct genre can pose challenges. This mixed-methods project sought to explore lower-division STEM students' perspectives about writing via an online survey and follow-up interviews as well as analyze their use of online (e.g., short videos, infographics) webtools that offered ideas and strategies to better improve their planning, drafting, and editing texts. The results indicated that students find academic writing to be a challenge. Their use of the online webtools and feedback offered through this project demonstrated improvement in their writing.

Keywords: writing; technology; strategy instruction

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Writing is a core skill that students need to succeed in school (Ibrahim et al., 2017). Teachers, students, and parents can all benefit from learning about online tools and writing strategies that can help them better manage composing text for specific purposes. The academic writing tasks of universities and colleges is one example. By expressing and sharing ideas and opinions clearly and concisely, students can demonstrate their ideas and findings to their audience (Alkhamra et al., 2012; Dennis & Swinth, 2001). Students' written texts are often a teacher's primary, or sometimes only, tool for evaluating their understanding of class content and academic achievement (Alkhamra et al., 2012). Students' progress and proficiency with writing helps them succeed in their undergraduate course work and future careers (Kellogg & Raulerson III, 2007). At the same time, adapting writing process, skills, and convention practices to discipline-specific expectations can be a challenge for students given the relationship between disciplinary knowledge and writing as a way of understanding and expressing disciplinary knowledge (Carter 2007; Hayes et al., 2017; Wolfe et al., 2014;). This adaptation process can be especially challenging for students writing in STEM courses, given the often distinct genre expectations and conventions. This study offered lower-division STEM students the opportunity to 1) offer their perspectives about writing in an online survey and follow-up interviews, 2) review short videos and infographics about writing strategies, and 3) receive feedback from an adult editor on their drafts of written assignments.

Many Students Struggle with Writing

Writing persists to be an issue of inequity for many students (Amalia et al., 2021; Fischer & Meyers, 2017). Bilikozen (2019) concluded that university students' underdeveloped literacy skills are a common point of complaint by academics at higher education institutions. Academic literacy, in the university context, refers to students' reading and writing skills and their ability to communicate competently in a community that relies on academic discourse (Calvo et al., 2020). According to Kumari (2016), students enrolling for the first time in STEM courses, for example engineering, can lack the kinds

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of writing skills needed to support higher learning within the respective disciplines. Beyond a lack of familiarity with STEM writing, students' writing difficulties may also result from their learning challenges with reading, writing (e.g., conventions or idea generation), or attentional issues. Alkhamra et al. (2012) suggest that learning challenges can be attributed to students' lack of practice to improve writing, reading, listening, and speaking skills. These students are likely to report challenges with perception, planning, studying, or editing. These problems intensify in secondary school where there is increased complexity in content and expectations for the successful completion of writing assignments. Support for writing instruction within disciplinary contexts, especially, can assist students as they navigate these complexities in content and tasks.

Many students struggle with writing (National Assessment of Educational Progress-Writing, 2021). The process of developing ideas, organizing them for a coherent text structure, spelling proficiency, drafting sentences and paragraphs, and making edits can be demanding for students who lack the efficient executive functioning (e.g., attention, memory) skills, in particular, to manage writing's multifaceted processes. These students can find reading, too, as a challenge, which results in fewer experiences and fewer examples of what good writing entails. About 4.2% of students may have a learning disability—difficulties with attention, perception, and working as well as long-term memory skills (Zablotsky & Alford, 2020). Providing students with a means to listen to texts (e.g., eReaders) and strategy ideas (e.g., short videos, infographics) can help offer these students options to help manage the writing process.

Second language learners can also face challenges in writing English texts (Al-Mubarak, 2017). Writing plays an indispensable function in foreign language learning within universities and colleges. These learners can face difficulties with vocabulary choice, grammar, use of irregular verb forms, and punctuation. Taken as a whole, these challenges to equity and inclusion can negatively affect the writing skills of students who have English as a second language (ESL).

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Pineteh (2014) suggests that the acquisition of appropriate writing skills promotes students' learning and comprehension across subject areas. For ESL learners, improving their writing skills is crucial for student success (Karakoç et al., 2017). These skills also allow a learner to better manage in other academic fields that require effective communication and comprehension. Instructors across all disciplines have a key role in this development process. By employing pedagogical approaches that promote active teaching and learning, faculty can support writing across the curriculum and the transfer of writing skills across courses. A key component is employing research/evidence-based practices that help address students' writing challenges.

How Writing can be Challenging for Students

Writing is a multifaceted skill for students to master (Graham, 2020). A key first practice to being a successful writer is to be a competent and avid reader. Reviewing published and high-quality texts in a given genre offers readers the opportunity to see and hear what a text can include, how it is organized and structured, and the type of vocabulary that is employed by experts. Analyzing published texts can be helpful for students to practice as they create their own prose to complete their writing assignments.

Struggling writers tend to have difficulty with idea generation and planning (De Smedt et al., 2018). Due to typically being infrequent readers, they sometimes do not have a sense of where to start in the writing process. This can be even more true when writing STEM genres given their often-technical vocabulary and content. Once a student has noted some ideas, their observations need to be formatted into a genre-appropriate plan or outline. These demands on executive processing in the brain along with spelling, word choice/vocabulary, sentence formation, and text structure of the overall order of subtopics renders real challenges for struggling writers. As a result, their resulting texts are often short, underdeveloped, and may be missing key elements.

High School and Lower-Division (STEM) University Students' Perspectives about Writing

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Writing is a core skill in academics, yet many students at the high school level do not write as frequently as expected, leaving them underprepared for writing tasks when they reach the university level (LeBlanc, 2021). High school students may lack sufficient time to learn how to criticize an idea, specify their stance on an argument, define a problem and propose a solution, or finesse their text into high-quality prose. They then enter an institution of higher education without the writing skills needed to help them achieve academic and career success in a chosen STEM field. Instructors in institutes of higher education can then find themselves struggling to offer strategies to help students with writing. One common strategy is the introduction of educational technology tools as supplemental resources (e.g., Grammarly.com; Purdue's OWL) to help students manage writing skills.

Writing Intervention Strategy Examples

For many people, writing is not an inherent skill. Students often benefit from being taught ways to manage writing tasks and then offered opportunities to practice and promote proficiency and adeptness. Graham et al. (2012) completed a meta-analysis about writing instruction methods. They found that those methods with the most positive impact included the following: strategy instruction such as self-regulated strategy development (SRSD; choosing a strategy that meets students' needs for improvement, discussing the strategy with students, modeling it, having students practice it with the instructor, and then students' applying the strategy themselves); use of imagery such as to illustrate ideas and content before drafting text; peer and adult feedback; and goal setting. Methods with low effect impact included the following: teaching transcription skills (e.g., create five topic sentences as a wrote/stand-alone activity apart from choosing a topic and drafting continuous text) and grammar instruction (e.g., focusing solely on wrote spelling and punctuation activities). Technology tools did not appear in Graham and colleagues' list, but their inclusion in the Common Core State Standards (2021) and Smarter Balanced Assessments (2021) make computers, mobile devices, and apps key parts of the current practice of writing.

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Other research supports the concept of strategy development, daily practice with writing texts, and use of technology. Schmidt (2021) investigated the practices of first-year college students who had low perceptions of high school writing practices. The author examined students' texts from independent writing sessions to assess their strengths and weaknesses. Schmidt concluded that most students could improve if provided inclusive practices such as teacher feedback, a choice in writing topics based on the students' interests, and materials and tools to help manage their writing. This research illustrates that technologies and educational tools can help address challenges to equity (Schmidt, 2021). When teachers employ strategy instruction and guided practice with technology tools, students have an enhanced opportunity to improve their writing skills.

Al-Jarf (2009) recommends the use of mind-mapping software among freshman students as a way of improving writing skills. Mind mapping software offers a type of graphic organizer composed of a central image and branches of text bubbles to generate thoughts and ideas, taking notes, improving memory, and developing concepts. For freshman students undertaking their first writing course in English as a Foreign Language (EFL), Al-Jarf (2009) revealed that before the integration of the mind mapping software, no differences were detected between the groups. However, after the application of the software, there were substantial variations in the students' generation of ideas, paragraphing, writing of topic sentences, and supporting written information with facts. Mind-mapping software can be a useful tool for learning and enhancing students' understanding of classroom concepts.

Gruenbaum (2012) validates the effectiveness of the Reciprocal Teaching (RT) technique in improving writing skills among students. With its focus on understanding texts, RT incorporates numerous approaches, including clarifying, predicting, questioning, and summarizing, which increase an individual's comprehension of texts. The method has teachers and students take turns while leading class discussions. At the same time, teachers also encourage and motivate their students to participate in peer learning and interactions. RT can be conducted on virtual-meeting platforms from where teachers and

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students can interact with one another, ask and answer questions, and discuss writing and comprehension issues. Other technological platforms, such as films, can also help instructors teach their students appropriate research skills that can enhance their writing skills through knowledge of grammar and mechanics (Baratta & Jones, 2008). Hawthorne et al. (2017) further suggest that self-regulated learning with rubrics can be a possible intervention to help address students' writing challenges. Using research that involved 596 undergraduate students enrolled in university coursework with an exam, Hawthorne et al. (2017) found that regardless of achievement levels, students benefited from the use of a detailed rubric as compared to those using a general rubric group.

Students can benefit from designated time to practice strategies. Graham and colleagues (2012), as well as Grunke and Leonard-Zabel (2015), concluded that offering students time to practice writing using research-based strategies and tools promoted the opportunity for students to improve their writing skills. The authors believe that teaching rote skills is not a best practice approach as it can lead to students' weaknesses in writing, which can continue with them into university. Rather, teachers should ensure that their practices address students' diverse needs and expectations for writing, including offering students time to engage in peer learning and participate in dialogue and feedback from the teacher to improve students' writing, academic skills, and opportunities in a future career. Multimodal resources, such as the webtools included in this study, can enhance students' writing development because they tap into multiple modes of learning (multiple literacies) for students to support comprehension and understanding. We administered an online survey and interviews to collect feedback on students' writing challenges and their use of the writing webtools provided in this study. The research team in this project sought to promote equity and inclusion by better defining what can help STEM students improve their writing skills in their first two years of coursework.

This study included the following three research questions:

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1. What do lower-division STEM students at a western US university view as their strengths and weaknesses in writing?
2. What resources do the lower-division STEM students seek when they find writing to be challenging?
3. After using some researcher-created webtools for this study, how did lower-division STEM students' writing skills change during the use of the webtools paired with an adult-editor's feedback on their drafts for a course's writing assignment?

Methods

This study focused on identifying STEM undergraduate students' perspectives about writing to help identify what types of webtools could be developed to help support and improve their writing skills. The study employed a sequential explanatory mixed method design (Kroll & Neri, 2009). The authors preferred the sequential/explanatory mixed method given the survey data followed by interview and writing intervention sequence of this study. In the interpretation phase, the data obtained from the interviews, questionnaires, and the online writing intervention was used in making a deductive comparison—reviewing students' pre/post-intervention texts to assess changes in skills over time.

The method included a sequential sequence of quantitative and qualitative data collection: a quantitative survey, semi-structured qualitative interviews, and descriptive analysis of writing-intervention participants' texts per a writing rubric (Association of American Colleges & Universities, 2021). The data from the qualitative component was used to analyze and explain the findings obtained in the quantitative phases. The authors received human subjects approval to complete this study.

Participants

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A total of 75 STEM undergraduate students participated in the study. The participants were lower-division (i.e., freshman and sophomore) students in STEM classes at a large public university located in the western region of the United States. Their age range was 17-56; mean=20.32; SD=4.86). The gender distribution was 27% male, 73% female. The participants' race/ethnicity is described in Table 1.

Table 1

Participants' Race/Ethnicity

White/Caucasian	66.20%
Black or African American	0.00%
Native Hawaiian or Other Pacific Islander	0.00%
Hispanic or Latino	14.08%
American Indian or Alaska Native	5.63%
Asian	7.04%
Two or more races	4.23%
Other descriptor: (Western European descent)	1.41%
Prefer not to answer	1.41%

The students' type of class is defined in Table 2.

Table 2

Participants' Type of Class

Class Type	Freshman	Sophomore	Junior	Senior

Science (e.g., chemistry, biology, astronomy)	36.07%	36.07%	22.95%	4.92%
Math (includes Physics)	46.15%	26.92%	15.38%	11.54%
Engineering	55.00%	25.00%	10.00%	10.00%
Computer Science	53.85%	38.46%	0.00%	7.69%
Other:	42.86%	21.43%	28.57%	7.14%

Procedures

The research team asked the instructors of two classes (astronomy and biology; N=200) to forward the email invitation to complete the consent form and survey. The quantitative phase involved administering questionnaires to the 75 student participants (38% response rate). The qualitative semi-structured interviews (N=8) were completed 1:1 with the first author. The interviews sought students' perspectives about writing (e.g., what did they find challenging about writing? What did they do when they needed help?). In the third component of this study, the researchers reviewed students' texts from an online writing intervention (N=3): three pre-intervention texts, and three post-intervention texts.

Instruments

Survey. The research team developed a 12-question, likert-scale survey (see Table 3) about students' perspectives about writing. The questions included topics such as experiences with reading and writing skills and how well students could listen/maintain attention in class, follow explanations in class, take notes, and manage writing tasks.

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Table 3

Survey Questions

Question Number	Question
1	Do you like writing?
2	Do you voluntarily seek and read academic texts similar to your writing assignments to see what published writers do?
3	What is your experience with the following aspects of writing? Focusing attention in class. Having the writing assignment explained in class. Attaining answers to questions about the writing assignment. Reading the required texts before completing a writing assignment. Finding source texts to reference in my own writing. Planning and organizing my ideas. Spelling words and creating sentences. Making a first draft. Reading my own writing. Knowing what edits to make. Attaining feedback (e.g., peer, campus writing center) Attaining a good grade on my writing assignments (e.g., B or better).
4	Was writing difficult for you in school?
5	Was reading difficult for you in school?
6	Gender?
7	What is your age as of September 1 fall semester?
8	What is your race/ethnicity?
9	You are a student in what type of class (e.g., biology, astronomy, etc.)?

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The research team asked a literacy researcher to review the survey, who affirmed that the questions were clear and focused on topics that could impact students' writing skills.

Interviews. The research team developed a set of questions to explore a small sub-sample of students' perspectives about their strengths/weaknesses with writing. The questions included the following: How do you feel about your writing skills? What is easy? Difficult? When you find an aspect of writing to be hard, what do you do? What resources have you found to be helpful? Why? What resources could be enhanced or created to help you more?

The interviews were conducted via online video-conferencing software (Zoom, 2021). Each participant met with the first author 1:1. The interviews ranged in duration between 20-30 minutes (mean=25 minutes). The descriptive information about each participant is listed in Table 4.

Table 4

Interview Participants' Descriptive Information

Participant	Gender	Race/Ethnicity	Year	Program Type
Yoshe	Female	Asian	Freshman	Computer Science
Roberto	Male	Hispanic	Freshman	Computer Science
Isabella	Female	White	Sophomore	Wildlife
Hannah	Female	White	Sophomore	Electrical Engineering

Xia		Asian	Freshman	Computer Science
Female				
Nisha	Female	Asian	Sophomore	Computer Science
Sophia	Female	White	Junior	Public Relations (Astronomy)
Aria	Female	White	Junior	Elementary Education (English)

Online writing intervention: students' texts. The biology and astronomy instructors each provided a rubric to students for their class writing assignment. The online intervention's webtools also included videos by each instructor discussing their rubric, a high-quality exemplar, and a low-quality exemplar. Online writing intervention students composed their lab report assignment in a password-protected OneDrive account, where a paid asynchronous editor could read the students' writing and provide weekly feedback to the students. Using the VALUE rubric for writing communication (Association of American Colleges & Universities, 2021), three members of the researcher team scored the students' writing individually and came to a consensus on the scores assigned to the writing products that were completed in different stages of the intervention.

Data Analysis Methods

Interview Data. For data analysis, the research team used a five-step framework analysis approach (Hruschka et al., 2004; Ritchie & Spencer, 1994; Rubin & Rubin, 1995; Silverman, 2000). They divided thematic analysis into five steps. They individually completed steps 1-4 and later met to compare notes and complete step five. First (familiarization with the data), they read all four teacher transcripts in analysis-ready form multiple times to become familiar with the content, made notes, and created initial

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categories. Second (coding to identifying a thematic framework), they coded key themes, concepts, and ideas from each page into categories as well as overarching sub themes. Third (indexing), after they reviewed the transcripts to create the codes, they analyzed their notes while cross-referencing back to the research questions to ensure the codes captured the participants' ideas. Fourth (charting), they summarized the data into a matrix for each theme by having a row for selected data from each participant, noting key ideas and/or illustrative example quotes, and using participants' verbatim keywords to correspond to the coded themes. Fifth (mapping and interpretation), the authors reviewed their matrices within and across participants to begin their interpretation of the data to develop coherent/agreed upon themes and possible explanations of interviewees' comments and ideas.

Attaining a good grade versus understanding course content. One-way ANOVA, correlation, and logistic regression analyses were used to determine differences in students' experience in attaining a good grade on the writing assignment based on students' self-reported Likert-scale scores. The items on the Likert-scale prompted responses about their ability to understand the course content, read the text, and draft, read, and edit their own writings, as well as inquiring about how the levels of difficulty for students to attain good grades on writing assignments could be affected by students' reading the assigned texts and their focused attention in class.

Results

The authors employed quantitative and qualitative methods to analyze the data from this mixed-methods study. The researchers sought to explore lower-division STEM student's perspectives about writing, what they find challenging, what could help them improve, and if participation in an online writing intervention with asynchronous webtools and a master's student feedback could help improve their writing skills.

Quantitative Results

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To address **research question 1**, we assessed the correlation of the variables using a sample of 75 college-student participants enrolled in STEM courses. Six of the variables among the ones investigated in the survey had strong correlations with students' grades in their writing assignments. The variables that showed statistically significant correlations with writing grades include students' capability of focusing attention in class to understand the content (r = .323), planning and organizing ideas (r = .265), making a first draft (r = .404), reading their own writing (r = .375), knowing what edits to make (r = .442), and the chances of attaining feedback from peers, instructors, or writing centers (r = .262).

Logistic regression analysis was then conducted to determine whether attaining a good grade in a writing assignment (having difficulty vs. never having difficulty) could be predicted from the aforementioned six predictor variables. Good model fit was evidenced by statistically significant results on an omnibus test of model coefficient, χ^2 (6, 75) = 26.99, $p < 0.001$, and large effect size indices when interpreted using Cohen (1988) (Cox and Snell R^2 = .32, Nagelkerke R^2 = .43), indicating that between 32% and 43 % of the variance in the dependent variable, whether students have difficulty or not in attaining good writing grades, can be explained by our independent variables.

Furthermore, we received a nonsignificant value of the Hosmer-Lemeshow test, χ^2 (8, 75) = 7.3, p = 0.505, which nicely supports a good fit of our model. The results suggest that the predictors, as a set, distinguished between college students who have difficulty in obtaining a good grade in writing versus never having difficulty. With the data in our analysis, we had a high percentage accuracy in classification (PAC) of 0.789, which indicates that 79% of the time when we make the predictions, we will be correct. It shows that our model has good predictive capabilities.

In terms of the relationships between the independent variables and the binary dependent variable, participants falling into the category of "sometimes having difficulty in reading my writing" provided us with conclusive information on prediction (p = .035, Exp(B)=7.16). The odds ratio of 7.16

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indicates that the odds of having difficulty in obtaining a good grade in a writing assignment (compared to never having difficulty) are increased by a factor of 7.16 if a student has difficulty in reading their own writing from time to time.

The rest of the predictor variables along with their categories were not statistically significant, which suggests that the odds for having difficulty in obtaining high scores in writing (relative to never having difficulty) are similar regardless of students' performance in focusing attention to understand the content, planning and organizing ideas, making the first draft, knowing what edits to make, and attaining feedback. Even though the results are not significant, likely due to sample size, they can still convey meaning for us to understand the impact of the covariates on improving writing grades given the small sample size in this study (Wasserstein et al., 2019). Specifically, we can consider that the odds of gaining a good grade are increased by a factor of 2.6 by the ability to focus attention during class to understand the course content. The odds that a student who knows how to plan and organize his/her ideas will obtain a good grade in a writing assignment are 1.11. The odds that a student who can easily make the first draft will receive a good grade are 2.19. The odds that someone who can easily read his/her writing will have a high score in a writing assignment are 2.19. If a student knows what edits to make, the odds for the student to have a high grade are 1.98. However, the odds of having difficulty in achieving a high score for writing are decreased by a factor of 0.84 by being able to attain feedback from peers or instructors.

Overall, with the current sample size, the category of "sometimes having difficulty in reading my own writing" has strong predictive capabilities to estimate the levels of difficulty that students encounter in their writing assignments. Other covariates, although yielding nonsignificant results, can still provide meaningful information for us to understand how they can predict students' writing performance in a science class.

Results for the Online Writing Intervention Participants' Texts

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Three students participated in the one-semester long, asynchronous, online writing intervention: access to 1) webtools (short instructor videos about the writing assignment's rubric, discussion of a low-quality example, high-quality example, effective habits of good writers) and 2) a master's student's asynchronous editing feedback and comments—**research question 3**. Their writing products at the beginning, in the middle, and at the end of the intervention were scored by the research team using the VALUE rubric (see Figure 1).

Criterion/Learning Outcome	4 (Capstone)	3	2	1 (Benchmark)
Context of and Purpose for Writing		Student B Student C	Student A	
Content Development			Student A Student B Student C	
Sources and Evidence			Student B Student C	Student A
Control of Syntax and Mechanics			Student C	Student A Student B

Figure 1. Themes related to helping students improve their writing skills

The students' baseline scores were low and scored 1 and 2 in the four aspects of the rubric: context of and purpose for writing, content development, sources and evidence, and control of syntax and mechanics. By the mid-point of the semester, three students demonstrated an increased score from 2 and 3, but one student's writing still scored 1 point at this stage. By the end of the intervention, all three participants' writing quality improved by 2-3 points.

Qualitative Results

The themes and subthemes from the qualitative data are presented in Figure 2.

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Themes	Subthemes
Students' perceptions of their writing skills	▪ Taking the time ▪ Generating ideas ▪ Proper grammar and syntax
Writing Instruction	▪ Students' comfort level varied by writing genre ▪ More specific instruction would help to manage rubric's multiple criteria ▪ Challenging to generate ideas
Resources that students find helpful	▪ Ask professor/instructor/TA ▪ Library ▪ Writing center ▪ Purdue's OWL

Figure 2. Themes related to helping students improve their writing skills

Interview Results

The qualitative portion, which addressed **research question 2**, revealed diverse views from participants regarding various aspects of the writing process. Most of the interviewees observed that writing was difficult and that resources were not always available. There were three overarching themes related to students' writing experiences: their perceptions about writing, its inherent challenges, and the types of resources they use.

Students' Perceptions about Writing and its Inherent Challenges

One of the main themes in the findings is the participants' impressions of writing and their perceived challenges. The interviewees concurred that writing poses a significant challenge and that most

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do not have the strategies needed to coherently organize their thoughts and ideas. As one participant remarked, “I have difficulty to start writing an assignment, generating ideas, and creating a structure” (Elementary Education student). It emerged that some students find it easy to write specific papers, more so research papers, but other writing assignments, such as opinion essays, pose a significant challenge. For example, one participant shared the following: “in general, I find writing pretty easy, especially like for like research papers I can make such it, it goes a lot smoother I think I definitely find a hard time like finding the motivation to start writing” (Astronomy student). Another participant observed “but opinion essay more difficult” (Computer science student). The generation of ideas and structuring of these ideas coherently emerged as one of the most critical problems:

> I think I don’t find any of it easy to be honest. To me would be difficult to write an essay trying to gather all the all the ideas I have and trying to put on the paper and make sure that later on, make sense. (Computer engineering student)

At the same time, the interviews revealed that students find it challenging to initiate the writing process. For instance, they experienced considerable challenges when deciding what they were expected to write about. The problem was encountered the most when students were asked to give their opinions about a particular subject area or topic. However, some participants agreed that their writing was good and that it came naturally to them. Hence, the interview revealed the varied perceptions students have regarding the writing process.

Writing Instruction that the Students Received/Need

The second theme focused on the type of training students received that affected their attitudes and competencies in writing. Students commented on how they worked to address the challenges they experienced in improving their writing. Some of the students depended on their peers and class notes to enhance their writing skills. The students stated the information provided in rubrics was overwhelming at

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times and that they found it challenging to follow everything in the instructions and requirements. As one participant shared, “the rubric did not always clarify the instructions” (Computer engineering student). The interviews further revealed that the teacher's notes, exemplars, and classmates' notes could be valuable sources of information: “some helpful resources are exemplars, teachers’ notes, and my classmates’ writing” (Computer science student). The students discovered over time that the teaching assistant was a helpful resource. As one student shared, “although I did not do well on my first/rough draft, the teaching assistant’s feedback helped me to attain a B+” (Public relations student). Instruction should meet students' needs to help them manage and have success in writing tasks.

Students agreed that the inclusion of user-friendly resources such as videos would enhance their experience and augment their writing skills:

> I think that having videos to explain different topics would be very useful. I have video of how to do math equations. I think this would be very useful for writing to help me understand how to manage the task. (Computer engineering student)

Students could be offered videos about what good writers do. Reviewing exemplars and why they are high or low quality would help. Students should have the choice to view discussions of exemplars at a pace with which they are comfortable to ensure they learn the skills they need to write. This would help them see that writing is a skill that takes time to master.

The Resources Students Use

The interviews indicated the multiple resources students use to help with their writing skills. One participant listed the following resources as helpful:

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> I use the internet for anything like structure grammar; Google is a prime example. If it is a question about the assignment's criteria, I prefer to go to teaching assistant rather than the professor, especially with bigger classes. (English student)

The library was also a valuable resource for the students because of the large number of materials. Some participants commented that writing resources such as Purdue's Writing Lab were challenging to navigate, but others said the campus writing center was the most important source of help (Computer Science student). Students commented that multiple resources can be helpful to improve their writing skills.

Quantitative and Qualitative Results: Similarities and Differences

The results of the quantitative and qualitative analyses had similarities and differences. In terms of similarity, both quantitative and qualitative findings emphasized that writing was challenging to most of the participants. The quantitative and qualitative analyses both indicated that students had difficulty understanding and editing their writing, and their ability to do these was associated with the grade they attained for their writing. The quantitative and qualitative results both illustrated how critical the first draft is and that students typically had difficulty generating ideas, which affected their writing scores.

In terms of the differences, the quantitative portion centered on the variables that affected students' grades for their writing assignments and the predictors pertaining to the quality of their writing. Although both analyses emphasized the pivotal role of editing, the quantitative analysis concluded that this variable is a significant predictor of students' writing grades; however, the qualitative results did not emphasize editing to the same extent. In addition to the predicative function of editing, the quantitative analysis also found that students' ability to focus attention on the course content and their capability to read the assigned texts were key factors associated with students' writing grades. The qualitative results indicated that there were many tools that the students found to be useful, including the teaching assistant,

the writing center, and their classmates' feedback. Receiving clear instructions for tasks and providing writing samples to students was crucial in attaining a higher grade in writing assignments.

Discussion

This study explored lower-division STEM students' perspective about writing and their change in skills during participation in an asynchronous online writing intervention with a master's-student editor's feedback. The findings indicate that students often have inadequate resources to help them learn and improve their writing skills. Students have difficulty when starting to write an assignment. They also face challenges with the complexity of information in classes, as it is difficult to understand and interpret when attempting to apply it to their writing processes and production. Resources such as the library and internet (e.g., Purdue's OWL) were helpful to students, but these kinds of online resources are not always easy to navigate (Singh, 2019). These findings suggest that universities should provide adequate and user-friendly resources to help students in learning and improving their writing skills (Changwong et al., 2018).

Similar to Alkhamra et al. (2012), the survey and interview results (**research questions 1-2**) illustrate that writing can be a challenging task for some students. They do access existing online webtools (e.g., Purdue's OWL), and they found value in the webtools developed and offered in this project for their specific STEM courses. Of note, many student participants voiced their lingering challenge of feeling a sense of learned helplessness: they do not feel empowered to invest a lot of time and energy into written assignments as they have not had good success with writing in the past. Webtools of strategy examples and the instructor's videos discussing what is required in written assignments can help these students with writing, but the bigger challenge remains of overcoming an attitude barrier of feeling powerless in starting well before an assignment's due date to plan and edit their text into higher quality prose.

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The intervention participants' VALUE rubric scores (**research question 4**) indicate some improvement. Like interventions for writing offered in public schools (e.g., grade 2-12) that have indicated positive improvement in students' writing skills, tools that offer lower-division university students ideas to help improve their writing can also have a positive impact. Similar to Graham et al. (2012), Schmidt (2021), and Al-Jarf (2009), offering students strategies that help them manage a task with planning, drafting, editing, and revising to a finessed product helps them learn the process, produce better quality, and have a higher senses of self-regulation skills in doing the task more on their own in the future.

Implications

Research shows that STEM faculty find writing to be effective in supporting students in learning content (Stroumbakis et al. 2010). Writing instruction research validates that writing facilitates learning while it confirms that writing is also a skill to be learned and developed (Moon et al. 2018). In particular, research on rhetorical genre studies (Bawarshi and Reiff 2008) and writing transfer (Beaufort 2008; Adler-Kassner et al. 2017) suggests that writing and adapting to new writing tasks and less familiar genres is a complex rhetorical process that students navigate as writers from discipline to discipline and class to class as undergraduates. As such, our study suggests that webtools informed by a strategy instruction approach can support students in the process of learning and adapting to genres that they have less writing experience with, such as can often be the case in lower-division STEM courses with writing assignments. That is, webtools that include resources such as strategy examples and instructor video explanations of writing tasks with discussion of genre expectations are especially valued by students and identified by students as useful writing instruction resources**.**

Limitations and Future Research

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This study was conducted at one university location in the western US during a pandemic. Students were experiencing several stressors during the timeline of the project which may have impacted their thinking about writing and the challenges that it can face. While a large percentage of students in the US public demonstrate severe challenges with writing, how that mapped to the students in this sample was left to participants' self-reporting of their writing ability as indicated in the survey and interview results.

Writing is a core academic skill in education along with reading and math. While writing has received renewed focus in public schools with the Common Core State Standards (2021) and Smarter Balanced (2021) assessments, intervention programming and strategy instruction continue to be mostly found in professional journals with a few housed in open sources across the web. Access to educators and classroom teachers for implementing best practices is therefore constrained. More accessible online intervention tools are needed to help students access when and where they choose for the types (genres) of writing they seek to complete. The development of webtools that provide multimodal writing-in-the-discipline strategy support, in particular, can assist students in negotiating audience awareness, purpose, and genre as they move through the planning, drafting, revising, and editing process of academic writing tasks.

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Young Adolescents' Digital Multimodal Writing in One Urban Setting

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Abstract

Today's adolescents are considered to be heavy users of social media technology and web-based applications, compared to middle-aged cohorts (e.g., 30-50 years old). However, exact usage details for young adolescents (10-15 years old) in the US are difficult to find, especially for socioeconomically disadvantaged students. There is also scant literature that examines young adolescents' multimodal composing with technologies, the audiences and contexts for which they intend their digital multimodal creations, and the values they hold regarding their creations. This pilot survey study is a response to this need for research. While overall the findings indicate some degree of diversity of form, purpose, and audience in composing among the young adolescents surveyed, these findings also reveal gaps in certain modalities for some groups of young adolescents. Additionally, the researchers call attention to a need for developing an audience awareness, especially of an online audience, and *multimodal* assessment acumen in these young writers.

Keywords: young adolescents, multimodal writing, technology, social media, urban

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Today's adolescents are considered to be heavy users of social media technology, the Internet, and web-based applications that enable them to read and produce a variety of multimodal texts, compared to over-30 and middle-aged (e.g., 30-50 years old) cohorts (Anderson & Jiang, 2018). Smith (2014) reported that adolescents find multimodal composition "engaging," that they experience it as "a collaborative, social process", and that it is "particularly beneficial for 'marginalized' adolescents," including English Language Learners (ELLs) and at-risk adolescents (p. 1). For the purposes of this study, multimodal composition or text is any digital creation that employs two or more modalities (e.g., audio, visual, gestural, textual) to convey meaning (McGrail & Behizadeh, 2017).

Exact details about social media use for young adolescents (10-15 years old) in the US are difficult to find (Rideout, 2016; Quinn & Oldmeadow, 2013), especially for socioeconomically disadvantaged students and for non-white students. In some cases, data need to be deduced from the results of surveys of social media use among slightly older teens (13-17), especially as performed by Pew Research (Vogels et al., 2022). What data we do have on the younger cohort of adolescents suggests that they closely track social media use as performed by the older group, in terms of proportion. However, because social media companies generally frown on social media use by kids younger than 13 and because parents often discourage social media use among children and young adolescents to prevent undesirable media effects such as "the violence, advertising promises, or pornography", among others (Valkenburg & Piotrowski, 2017, p. 252), young adolescents typically spend less time on social media than teens, and more time watching television (Rideout, 2021).

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Martin and Lambert (2015) also observed differences in prior use and exposure to technology among students from different demographic groups. Pew Research Center's data (Vogels et al., 2022), for example, reveals that "higher shares of Black and Hispanic teens report using TikTok, Instagram, Twitter and WhatsApp compared with White teens" (p. 4). Vogels et al. (2022), writing for Pew, point out that gender is also a strong predictor among teens for specific social media use, with boys stating a preference for YouTube, Twitch and Reddit and teen girls stating that they preferred TikTok, Instagram and Snapchat. Research on digital multimodal writing and young adolescents in schools with insufficient technology resources has been limited though, and the findings on adolescents and technology use at large have been inconsistent (see the National Opinion Research at Chicago survey (NORC), 2017; Purcell et al., 2013).

Yet, teachers rely on technology use information to determine what aspects of digital multimodal writing to emphasize in their instruction and how to differentiate such instruction to meet the needs of all young writers. Different multimodal genres require developing the design competencies, knowledge of genre conventions and writing processes unique to particular forms of multimodal expression (McGrail et al., 2021; McGrail & Behizadeh, 2017). These skills aid students' comprehension of the multimodal text as young writers have the opportunity to experiment with different modalities to make meaning and to learn how these semiotic systems interact with one another (Serafini, 2012) and how to use them to attain their communicative goals. Writing for social media outlets both expands and complicates the traditional notions of audience as well as reader and writer boundaries (McGrail & Behizadeh, 2017; McGrail & McGrail, 2014; Marwick & boyd, 2010).

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Young writers are developing these competencies at different paces, depending on their technology expertise, multimodal composing proficiency, and exposure to diverse audiences and digital writing contexts (Martin & Lambert, 2015). Discrepancies in technical skill and resources available can affect how young writers are able to create meaning (Smith, 2019). Considerations of the social reality, including access to and knowledge of technology, among young adolescents from economically disadvantaged contexts are critical to understanding these learners' engagement of technology for multimodal composing. Teachers' acquiring an in-depth understanding of young adolescents' exposure to technology and multimodal composing is thus necessary in order to support writing development of these young multimodal content creators. This knowledge may also support reading development as writing improves reading comprehension and reading skills (Graham & Hebert, 2011; Dean & Grierson, 2005). This is because "reading and writing are deeply reciprocal activities" (Graff et al., 2018, p. xxi). Little is, however known about young adolescents' use of technology for multimodal composing in economically disadvantaged educational contexts.

It is therefore essential that educators and teacher educators are able to "get a handle" on the fast-moving portrait of media use among young teens, especially as it impacts the technologies involved in digital multimodal writing. In response to this need, the researchers of this exploratory pilot survey study inquire about prior exposure to and use of technology for digital multimodal writing among young adolescents with limited technology resources in one US-based urban educational setting. Our research questions are the following:

1. What forms of multimodal creations did these young adolescents produce?

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2. Which purposes, audiences, and contexts did these young adolescents engage for their multimodal creations?
3. What values did these young adolescents assign to writing and their multimodal creations?

We note that the survey and its analysis that we report on here were completed before the COVID-19 international health emergency. However, "while teens' access to smartphones has increased over roughly the past eight years [(95% now and 73% then], their access to other digital technologies, such as desktop or laptop computers or gaming consoles, has remained statistically unchanged" (Vogels et al., 2022, p. 6).

Multimodality, Writing and the Pandemic

Scientific studies have shown that the COVID-19 pandemic has had an overall deleterious effect on student learning worldwide, as it disrupted schools and may also have led to a disproportionate negative impact on children from a lower SES (Bem-Haja et al., 2022).

Regarding pandemic-related concerns on reading and writing in international contexts, Martí-Gonzaléz et al. (2020) found that "[the teaching-learning process of reading and writing in "a hybrid or online way" proved to be "a major challenge for teachers and families and, of course, also for children who were in the process of learning. (p.1). This is despite the fact that both in the US (Rideout et al., 2022) as well as abroad "many young people used their devices directly to make art or music, such as taking and editing photos, making videos, or composing music" (Martí-Gonzaléz et al., 2020, p.20).

As for reading itself, whose intensive use often predicts increased writing (Graham, 2020), little seems to have changed since the pre-pandemic social media era. According to the

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Common Sense Census reporting on the data gathered among youth in the US (Rideout et al., 2022), reading (which was conceptualized to include print, digital and eprint technologies) in 2019 stood for young adolescents at about 35%. In 2021, it stood at 34%. Fortunately, then, the pandemic does not seem to have eroded the practice of reading, but other media use increased significantly.

In an international study, Skar, Graham and Huebner (2023) performed a recent replication study on children's writing during the pandemic. While their cohort was much younger than ours, dealing with first and second graders, they found that indeed purely online instruction had a negative impact on these children's writing quality and handwriting fluency. In the US, the COE of the Common Sense corporation Steyer has noted that during the pandemic:

> For parents, caregivers, educators, and even policymakers across the country, kids' media use has been among some of the issues at the center of this conversation. As school went remote, as activities were canceled, as new variants forced kids and families back indoors, it was clear to anyone who spent time with kids that screens were taking up more and more time in their days (Rideout et al., 2022, p. v).

Reflecting this, the Common Sense Census report on young adolescents and teens notes that:

> From 2015 to 2019, media use for tweens grew only 3%, and for teens, 11%. But from 2019 to 2021 alone, media use grew by 17% for tweens and teens. On average, 8- to 12-year-olds use about five and a half hours of screen media per day (5:33), while 13- to 18-year-olds use about eight and a half hours of screen media (8:39) (Rideout et al., 2022, p. 3).

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Rideout and Robb (2021) found in a survey of US young adolescents that students during the pandemic still found time to create a great deal of digital content. Some of this material included anime, poetry, musical beats, photography, and shooting and editing videos. They reported that many of these young people used their smartphones and other devices to make art and music. Specifically, "About half (53%) of all 8- to 18-year-olds said they did so, including 19% who did so "often" (p.20). In terms of demographics of the surveyed youth, "Again, girls were more likely than boys to create digital content (24% vs. 14% do so often)" (p. 20), and similarly to the earlier reported trends (NORC, 2017), "Black tweens and teens were more likely to do so than their White or Hispanic/Latino peers (28% often do so, compared with 17% of Hispanic/Latino and 18% of White young people)" (Rideout & Robb, 2021, p. 20).

Technology and Socioeconomically Disadvantaged Young Adolescents

While some of the news on social media creation by lower-SES students is hopeful, some researchers have provided a less positive account of adolescents' access to and use of technology among socioeconomically disadvantaged students. For instance, researchers of a national study that examined Advanced Placement and National Writing Project teachers' perspectives on digital writing habits of middle and high school students reported that 56% of teachers were concerned that the lowest income students were unlikely to "have sufficient access to the digital tools they need, both in school and at home" (Purcell et al., 2013, p. 3). Alternatively, studies have indicated that factors other than access to technology are redefining the digital divide between today's high-income and low-income students and schools (Rowsell et al., 2017). Factors that can undermine effective student technology use include firewall barriers and mobile device use restrictions, limited speed and bandwidth capacity, including having or not having

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enough connectivity to meet student needs (Bach et al., 2018), the quality and type of software that is available, as well as the instructional uses to which technology is put (drill and practice applications in low SES schools vs. simulations in high-SES schools (Dolan, 2016; Project Tomorrow, 2013; Warschauer & Matuchniak, 2010).

The picture is not always bleak nor clear-cut, however. Indeed, the researchers of the NORC survey (2017) among older adolescents found that Black youth were both more active in social media, used more social messaging applications and reported more frequent use of smartphones than white teens. It is not clear if similar trends are observable among young adolescents.

Young Adolescents and Digital Multimodal Composition

The use of social media technologies to create content has reverberated into the classroom, where digital filmmaking (Husbye & Vander Zanden, 2015), photography (Alley, 2018), video and blog projects (Ranker, 2015), as well as comic book creation (Bitz & Emejulu, 2016, McGrail et al., 2020), among others, are becoming common experiences for many students today. In a review of empirical literature on adolescents and digital writing, other reported types of multimodal products that students created across different contexts [inside/outside school and afterschool programs] included: “video game/virtual world; PowerPoint; website; online fan fiction; blog/online journal; e-comic; podcast/radio show; Claymation video; photo collage; hypermedia; social networking; 3D animation; and digital book” (Smith, 2014, p. 6). The creations were “frequently made public, distributed widely, and designed for authentic purposes” (Smith, 2014, p. 7). What is thus intriguing in the studies Smith cites is the prosocial character of this technology use among adolescent content creators.

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Prosocial discourse can also result in the invocation of authentic audiences (Lunsford & Ede, 2009; McGrail & McGrail, 2014). This was true of the adolescents who engaged in online poetry sharing with readers and reviewers within a fanfiction affinity space (Padgett & Curwood, 2016) and of the high school youth who participated in Twitter literary conversations with graduate student audiences from the local university (Hunter & Caraway, 2014). In a study by Kaplan and Zangerle (2015), middle school students had the opportunity to work on community-oriented inquiry projects, which resulted in the creation of public service announcements (PSAs) on the pressing issues or problems in the local communities such as alcohol and drug abuse, animal abuse, bullying or divorce (Kaplan & Zangerle, 2015). The PSAs were designed for an authentic young adolescent audience in the community and beyond and the students shared their final stories with their immediate peer audiences.

Social media platforms such as twitter, blogs and Instagram have thus both expanded and challenged traditional notions of the writer's audience and reader-writer boundaries (McGrail & McGrail, 2014; McGrail & Behizadeh, 2017). This is because these platforms encourage many-to-many communication with diverse audiences (Marwick & boyd, 2010). "Much like writers, social media participants imagine an audience and tailor their online writing to match" this imagined audience's expectations (Marwick & boyd, 2010, p.128). The actual readers and viewers of writing in social media spaces are however much more diverse and even unpredictable than the audience the writers envision or invoke for their writing on social media.

Understanding to which audiences young adolescents aim their digital multimodal creations and which social media platforms they choose as venues for their writing will shed light on how young adolescents position their writing in social media environments and what

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expectations they have from the audiences for whom they compose on social media. Implications from these insights are important for teaching the concepts of audience and multimodal production, publishing and distribution, as classrooms are becoming more and more spaces of connected learning when teachers incorporate into instruction social media platforms and collaboration- friendly multimodal production technologies.

Yet the picture of multimodal composing with social media technology is not consistent. Martin and Lambert (2015) observed differences among students from disparate demographic groups, where heavy technology users composed for various audiences, including online audiences, and in "multiple modes and genres" while infrequent users and those who had limited technology experience produced "continuous text written in a large, purple font" (p. 217). Martin and Lambert (2015) called the first group of users "digital drivers" and assigned them characteristics such as "independent technology use; high digital text consumption, and high digital text creation." He called the second group "digital passengers" due to their "dependent technology use; limited digital text consumption; and minimal digital text creation" (p. 221). In addition, these researchers identified a group of students they found to be somewhere in between the two high- and low-end groups of technology users and multimodal content creators. He called these "digital navigators," based on their independent technology use; moderate to high digital text consumption;" but "limited digital text creation" (p. 221). The researchers concluded that the varying degrees of prior technology use across students from different demographic groups necessitated differentiated pedagogy to meet all student writers' needs when they composed digital multimodal texts.

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Gutiérrez (2008) has used the term "third space pedagogy" to describe a classroom community that expands the learning space beyond the classroom walls and uses "multiple mediating tools," that is, using the tools available at home. Smythe (2010) explored the concept of third space in the context of podcasting in her middle school ELL classroom, finding that "podcast time" changed the classroom power dynamic and encouraged distributed knowledge, social interaction, and collaborative learning.

In a study on seventh-graders' digital multimodal compositions, Castek and Cotanch (2013) found that collaboration engages "those students who may be less proficient with alphabetic writing but who have unique perspectives to share and rich ideas to communicate" (p. 186). Similarly, Zammit (2011) reported increases in engagement and self-image among students from low socio-economic backgrounds when teachers incorporated multiliteracies and multimodal writing digital tools into instruction. This is because the students were able to create "multimodal texts that changed what was seen as legitimate school texts and thus credited them as literate individuals" (p. 203). These latter studies represent though more of the teacher's than of the student writer's perspective. More research is needed on young writers' self-perception and appraisal of multimodal digital writing, attending especially to students' voices from schools with limited resources. How young writers view their writing experiences in general and writing that engages multiple modalities and multiliteracies influences their motivation and enjoyment of writing (Castek & Cotanch, 2013; Zammit, 2011). Motivation and enjoyment of writing lead to greater effort and more goal-oriented learning, resulting in improved writing performance (Graham et al., 2017; Wright et al, 2019).

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In order to support student writer "design processes and decisions entailed in systems and structures of [multi-representational] meaning" (Jewitt, 2008, pp. 248-249), teachers and teacher educators ought to seek a better understanding of young adolescent writers' prior experiences with technology and digital multimodal production, the audiences and contexts for which they intend their digital multimodal creations, and the values young writers hold regarding their creations. There is scant literature, though, that explores these aspects of the composing process among young adolescent multimodal content creators using today's technologies. Our work, which is situated in a Title I urban school setting in a large city in the American south, is a response to this need.

Multimodal Technologies, Writing and the Way Forward

It is our wish that literacy educators, researchers and school administrators use findings from our own and the above research to identify the resources and writing support needed to aid multimodal composing among young adolescents and adolescents at large, and specifically for socioeconomically disadvantaged young adolescents in their own educational contexts. Instruction about multimodal composing can further enhance students' ability to read and interpret critically their own multimodal texts and those of others (Pantaleo, 2017). Creating multimodal texts may also support what Eisner (2003) referred to as learning to "think within a specific medium," which is knowing how to conceptualize and convey meaning using the affordances of meaning making tools such as for example, image, sound, movement and other media (p. 343).

Theoretical Frameworks

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This research is an exploratory study, as we were interested in young adolescents' experiences with technology and multimodal composing along with their attitudes towards these topics. We therefore chose a survey instrument for collecting the data and surveying students. The survey enabled asking multiple-answer questions about technology uses and multimodal composing, yielding more data to analyze than would otherwise have been possible in short interviews with the participants. Even though we report frequencies, we are interested in investigating the diversity, rather than the distribution of technology use and multimodal composing in a population of young non-white adolescents in one urban context (a particular case). This is a characteristic of the qualitative survey or "the diversity survey" (Jansen, 2010, para. #2). Similar to structured interviews in qualitative research, our survey questions were "defined beforehand and the aim of descriptive analysis is only to see which of the predefined characteristics exist empirically in the population under study," (Jansen, 2010, para. #9).

Socially employed technologies and their outcomes, i.e., the forms of multimodal creations that we examined through research question (RQ) 1 in our work, reproduce the discourses that users ascribe to them (Lynch & Kinsella, 2013). However, the idea of *discourse* that we have in mind reflects Gee's (1989) pre-social media construct of discourse that, when translated for our study, manifests as ways of using, thinking, and acting upon technology that were socially meaningful and acceptable for the young adolescent technology users and content creators we surveyed. In a later work, Gee (1990) augmented the term Discourse with a capital "D" and associated it with "various objects, tools and technologies" (p. 155). This latter definition is of special interest to this analysis, since it places technology in a group with other

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values and beliefs essential to composition for our young writers. Technology, then, is never just a neutral enhancement; it changes both the writing and the writer (Lynch & Kinsella, 2013).

From the digitally rhetorical and pedagogical perspective that informs this work, technology use is also continuously related to the *rhetorical situation* within which it is applied (Morrison, 2010; Palmeri, 2012; Selfe, 2007). (Consider that we only rarely respond to a text message with a phone call, even though we are usually technologically able to; doing this might be described as "rhetorically inappropriate.") At its roots, then, technology use may be defined by the rhetorical situation it serves and the rhetorical context in which it is being enacted. Our RQ2 explored the purpose, audience, and context in which young adolescent writers employed various technologies— the rhetorical situations within which they employed these technologies.

Finally, as evident in RQ 3, we were interested in the *value* (i.e., ways of thinking, believing, and valuing, using Gee's terminology) young adolescent writers assigned to writing and the multimodal creations they developed with particular technologies and how their value system compared to the evaluation of their work by the other, the insights these writers gleaned through the comments they had received from the members of the larger Discourse community (Gee, 1989, 1990) whom they were addressing, namely, the audience. Echoing Lynch and Kinsella's (2013) rhetoric of technology, we saw the value these young adolescent writers assigned to their multimodal creations as a form of "agency," enabling them to contribute to "inventing and disseminating" (p. 4) their creations and the discourses around these creations and ideas contained in them. We discuss these contributions in the findings.

Methodology

Data Collection

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Sample and the context. Our sample consisted of 66 schoolchildren attending a middle school in a large city in the American South. One hundred percent of the students in our cohort were eligible for the free lunch program. The student sample we collected is a convenience sample (Blair et al., 2014) in that we worked with those teachers who responded affirmatively to our invitation to participate. The school was chosen because it was a middle school in a major urban area accessible to us and it served a disadvantaged student population.

Participant demographic characteristics. Our student participants were entirely nonwhite, and overwhelmingly Black. Of the 66 respondents, 4 (6%) reported that they were Latino/a, one (1.5%) reported that they were Native American, one (1.5%) reported as Asian, and 62 (94%) reported that they were Black or African American. Because the students were permitted to report more than one ethnicity or race, in one case (1.5%) a student self-reported as more than one race (Native American, Latino/a and Asian).

All 66 participants (100%) reported as belonging to either the male or female gender (male=30, female=36). There were 15 participants from the 6th grade, 29 participants from the 7th grade and 22 from the 8th grade. However, while girls were equally represented in each grade level (12 participants each), the boys' participation varied greatly, with just three boys in the sixth grade, 17 in the seventh grade and 10 in the eighth grade. 14 of the 15 sixth graders (93%), 27 of the 29 seventh graders (93%), and all 22 (100%) of the eighth graders identified English as the language they felt most comfortable with. A plurality, or 25 of the mothers (38%) and 29 of the fathers (44%) had graduated high school or had their General Equivalency Diploma (GED). In terms of the highest degree for either parent, one mother had a professional

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degree (MD or JD) (1.5%); and one mother and three fathers had a doctoral degree (Ph.D., Ed.D., D.D. etc.) (1.5% and 4.5%, respectively).

The survey instrument. The 20-minute survey, which was administered in paper form, requested basic demographic information, including grade (6th, 7th or 8th grade), race (with multi-race options permitted), parents' educational background (from grade school through doctorate or equivalent), and self-reported language competency (multiple languages permitted) and the primary language spoken at home.

The background section of the survey inquired about access to technology at home and school and about the precise technologies with which the students were familiar, including hardware, such as video cameras, phones, and laptops, and software applications, such as those for text, video, audio, graphics and digital photography. We refer briefly to the results from this portion of the survey in our discussion in this work.

The survey then proceeded to probe the students' creative process in depth (10 questions, employing matrix and point-scale type items). One such query investigated types of creations (e.g., video, photo or music creation), *How many times did you produce any of the following creative pieces in the past year?* and *How did you make the following creative pieces in the past year? (Hand-drew, Used Software, Both).* Another inquired into the venue (blog, wiki, website, twitter, Myspace, Instagram, Pinterest, Snapchat, YouTube), *Where did you post any of your creative pieces in the past year?* and the audience selected for dissemination, *Who did you make your creative pieces for in the past year?* ("teacher," "online friends," "offline friends," "family," "myself only," and "everyone else").

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We also queried the students about the purpose of their creations, *Why did you produce the following creative pieces in the past year?* ("for school," "fun," "to learn," "to be part of a group") and their attitudes toward writing in general, *Which of the following statements represents how you feel about writing?* (from "*I hate writing*" to "*I love writing*"); and their work, that is, how pleased they were with their creations, *How pleased were you with the creative pieces you produced in the past year?* (from "very pleased" through "very displeased") and what they valued the most about their creations, *What did you like the most about your creative pieces?* (the "visual impact," "ideas/message," "structure/design," "audience comments," "technical skills").

In addition, these pre-adolescents were asked to comment on what they thought the audience liked the most about their creations, *What did other people tell you they liked the most about your creative pieces?* (the visual impact, ideas/message, structure/design, audience comments, or technical skills). The purpose of the latter questions was to compare the value systems, contexts and audiences that young adolescents assigned to their creations with the evaluation systems that others associated with their creations. As such, these questions probed into the larger Discourse communities whom the young adolescents had presumably been addressing or were expected to address.

Data Inspection and Analysis

The data were collected from the 66 surveys and were entered into SPSS software for inspection, cleaning and initial analysis. However, the tests we performed on the survey responses were mostly non-parametric, because we were primarily working with categorical and

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ordinal data.[1] Because the cohort tended to be young and inexperienced with surveys, some errors emerged, such as leaving questions blank when they meant to convey that they did not use the technology in question. Where such errors occurred, we grounded our decision on intent based on the number of exactly similar errors in other survey responses from the same cohort.

We also received missing data responses (11 missing for the mothers, or 16.6%, 18 missing for the fathers, or about 26%; n=66) related to their educational level. Since the non-missing educational statistical data on the education level of parents in our sample roughly mirrored the ratios in official state figures, we used sample imputation, moderated by these state and federal data, to construct an estimate of the missing data (Liao et al., 2014).

Survey Instrument Validity

To ascertain face and content validity, that is, checking for the "instrument's ease of use, clarity, and readability" as well as "accuracy, relevance, and breadth of knowledge" regarding the constructs within the questions asked and variable measures (Burton & Mazerolle, 2011, p. 29), we consulted with a group of colleague researchers and teachers who taught in middle school and whose interests and expertise are in writing and middle-level language arts. Several revisions, eliminations, or additions of the questions (and individual items) were made, resulting in a shorter and more focused survey than the original instrument, with "kid-friendly" language and directions.

Limitations

[1] Two exceptions were Query #12, "How comfortable are you using the following software or apps?" and Query #21, "How pleased were you with the creative pieces you produced in the past year?" because the permitted responses exhibited a true midpoint and therefore were susceptible to the Central Limit Theorem, permitting parametric analysis.

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The survey was administered to the students from one middle school, and would therefore not be statistically generalizable; however, our sample is representative of that school's total population. According to the district school profile, the student gender breakdown at the school was 49% female and 51% male. Ethnically, the school was 98% Black and 2% Latino. These statistics hewed closely to those in our survey. One hundred percent of the students in our cohort were eligible for a free lunch. The school served just over 300 students in grades 6 through 8. As with all surveys, there is also the issue of self-reporting bias (Blair et al., 2014) where the participants might have provided socially desirable responses, or they may not have been able to assess accurately their multimodal work. The survey question that asks the participants to report what others think of their multimodal work was used to minimize to some degree the latter effect.

Findings

We organized our findings around the research questions that address these areas of interest: 1) the forms of multimodal creations; 2) the audience, purpose and context for multimodal creations; and 3) the value systems assigned to writing and the multimodal creations.

The Forms of Multimodal Creations (RQ 1)

Modes and modalities. Since we were interested in the kinds of creations young adolescents produced and the modes and modalities they employed in these compositions, we asked the students how many times they had made a video piece, music piece, photo piece, comics piece, fan fiction piece, animé or manga piece, digital story, or another type of creation in the year prior to the administration of the survey (see Table 1 in Appendix). We reported not only the frequency of use as an aggregate number, but also how many students refrained from

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the use of a particular multimodal type. We also grouped frequencies that were above zero use, namely "1-2 times" "3-4 times" and "5 or more times."

The most common types of multimodal creation reported by our young adolescent creators were, in descending order, photos (54, or 81.8% of students), videos (50, or 75.8%) and music (47, or 71. 2%). In descending order, the remainders in popularity of use were digital stories, comics, fan fiction, animé/manga, and "other." There is an important caveat, however. Popularity of use did not fall off evenly; the least popular named multimodal type, animé/manga (18.2%), was still used by 12 students 1-2 times, but significantly fewer (4) students reported heavier ("5 or more times") use of this type.

With less used types of creative works, the overall *frequency of use* was less, but this was due to a *decreasing total number of participants* using them but using them more often. Conversely, with respect to photos, videos and music, a majority of respondents (47, or 71.2%) did not make *any* of these top three types of multimodal creations, but the consistent employment of these modes by the remaining students made them the most popular type used overall.

Interestingly, the percentages of those who did not create complex multimodal creations were rather high in certain composition types. These included in descending order, animé/manga (65.2%), fan fiction (62.1%), comics (57.6%), and digital story (53%). Additionally, the vast majority (63 respondents, or 95%) reported that they had created no "other" type of multimodal composition.

Modality Moves. We were also interested in how often students moved from one modality to another to create compositions, that is, whether the desire in students to create digital multimodal compositions tended to "jump" categories; or whether the impetus to create one kind

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of composition stayed with that particular modality. We ran non-parametric correlations (Kendall's tau) between and among the differing categories of multimodal compositions, and we found that with a rigorous level of significance (.01) those students who frequently created certain kinds of digital multimodal compositions tended to frequently create other types as well. For example, those who created video compositions were moderately likely to create photos (.379), comics (.395), and music (.311). Weaker but equally significant correlations were found between video makers and those who created digital stories (.267), fan fiction (.229), and animé/manga (.224). A moderate to strong correlation was also found for comics creators and other genre makers; comics creators tended also to create fan fiction (.576), and music (.454) (all correlations are non-parametric at $p \leq .01$).

The use of non-alphabetic text. Another aspect RQ 1 explored was the frequency in which non-alphabetic texts were used in young adolescents' multimodal creations. We define non-alphabetic texts as those that do not include significant or large amounts of textual information. For the purposes of our assessment, we limited this to video, photo and musical compositions. As indicated again in Table 1 in Appendix, we found that among our 66 respondents, photos were the most commonly created non-alphabetic text composition, as 30 students, or 45.5%, said they created them 5 or more times and 54, or 81.8% said they had taken at least one photo. The second was video, where 19 students, or 28.8%, had taken 5 or more videos and 50 students, or 75.8% had taken at least one video. Third was music, where 15 students, or 22.7%, said they used 5 or more examples of this element, and 47 students, or 71.2% said they had created at least one musical composition.

The Purpose, Audience, and Context for Multimodal Creations (RQ 2)

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The overarching rhetorical context research question included examination of the purpose, audience and venues young adolescents chose for publishing their multimodal creations.

The purpose. We asked our participants for what purpose they produced their creative multimodal pieces, breaking them down into videos, music, photos, comics, fan fiction, animé/manga, digital stories, and "other." The choices we provided were "for school," "for fun," "to learn" and "to be part of a group" (see Table 2 in Appendix). We did not provide a neutral choice, but we interpreted leaving the question blank as being "none of the above." We also allowed for multiple categories for each affordance (technological genre).

Overwhelmingly, in every category (see Figure 1 for the Stated Purpose for Top Three Creations), the most commonly selected choice as to the purpose of the creation was "for fun," except in the "other" category, where "for fun" was second only to "to be part of a group." With video, it characterized 34 impressions (51.52%), or a bare majority of impressions; in music, it characterized 31, or 46.96%; in photos, 36, or 54.55%, a majority of impressions; in comics, 25, or 37.88%; in fan fiction 22, or 33.33%; in animé/manga, a similar 22, or 33.33%; in digital stories, 17, or 25.76%, and in "other" creations, 6 or 9.09%. Except for the "other" category, "for fun" constituted either a plurality or majority of reasons given for the undertaking of the multimodal creation.

Interestingly, while students were permitted multiple responses, they only rarely selected "for fun" in conjunction with another value. For video, 2 or 3.03% gave "for school & for fun" and 2, or 3.03% gave "for fun & to learn." In music, 1 or 1.52% gave "for fun & to be part of a group" and 1 gave "for fun & to learn." In photos, 1 gave "for fun & to learn" and 1 gave "for

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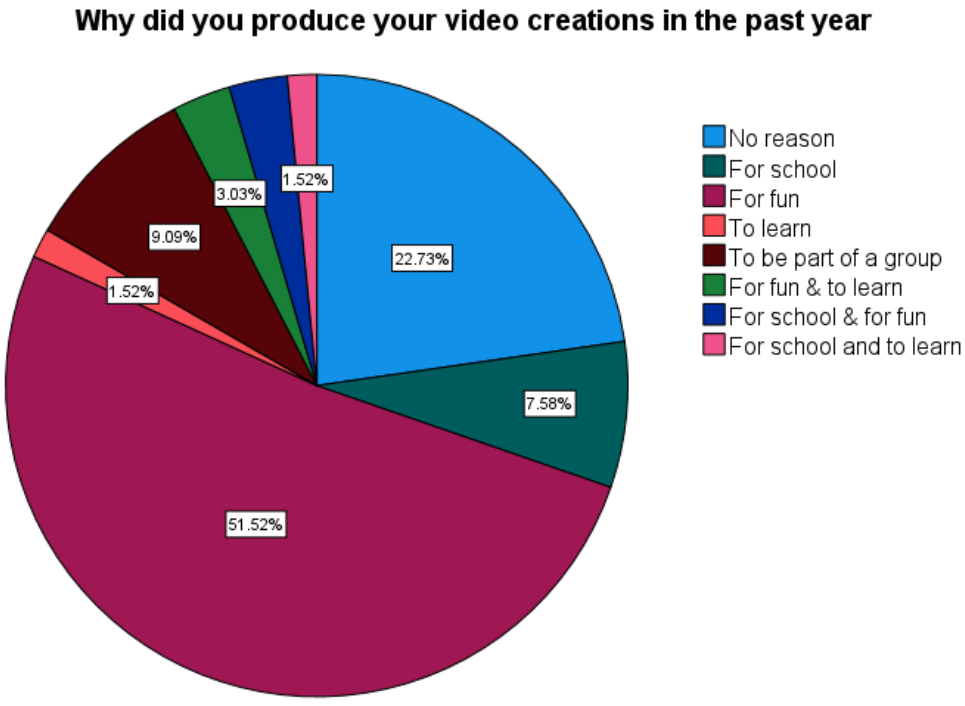
school & for fun." In digital stories, 1 gave "for fun & to learn," and 1 gave "for school & for fun."

Another finding with this research question is that the purpose query was left blank by a comparatively large number of children. Fifteen, or 22.73% left it blank for video; 20, or 30.30% left it blank for music; 16, or 24.24% left it blank for photos; 27, or 40.91% left it blank for comics; 30, or 45.45% left it blank for fan fiction; 29, or 43.94% left it blank for animé/manga; 28, or 42.42% left it blank for digital stories. A majority, 51, or 77.27% left it blank for "other creations.

Figure 1

The Adolescents' Stated Purpose for Top Three Creations



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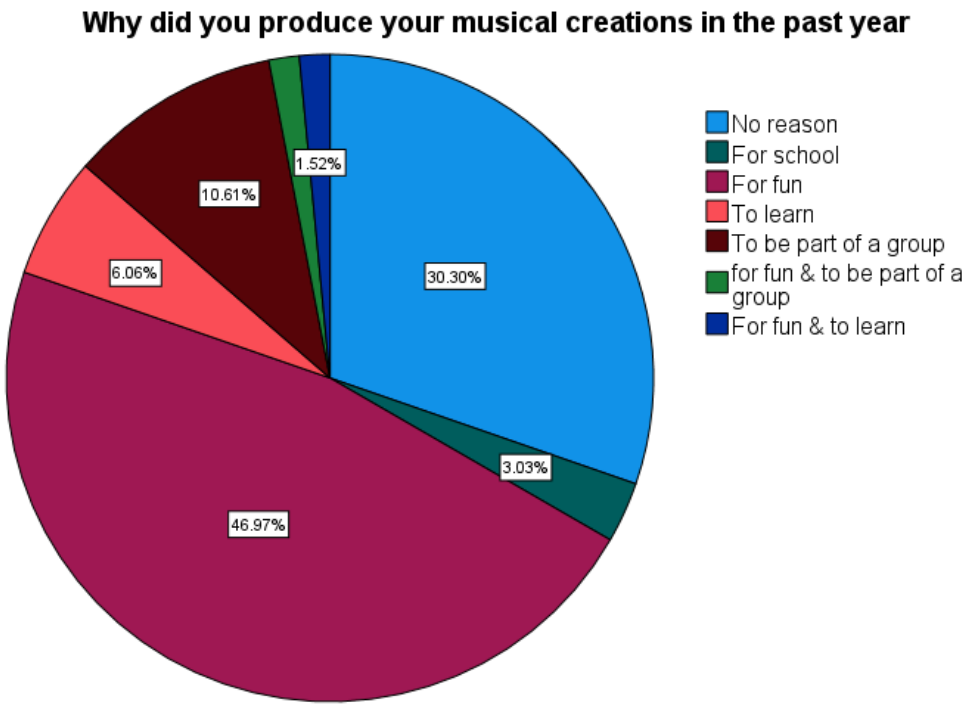

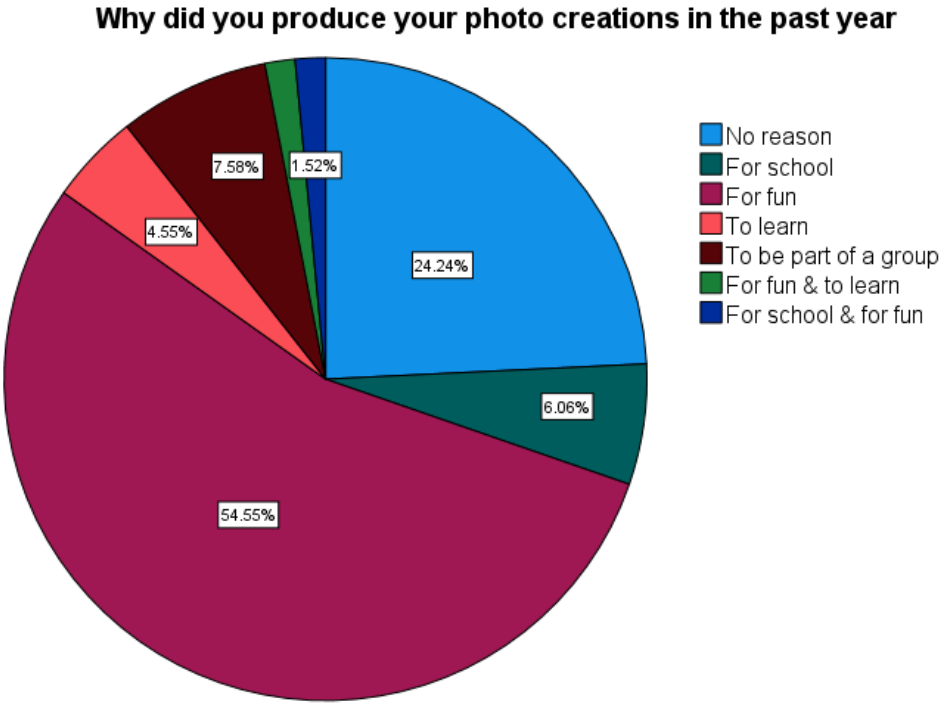

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Note. These are most commonly selected purpose choice for the top three creations.

The audience. We then asked our respondents for whom they had created their multimodal compositions in the past year. The possible responses were "did not respond," "teacher," "online friends," "offline friends," "family," "myself only," and "everyone else (the public)." We asked them to associate their chosen audiences with the particular modes and modalities, namely video, music, photos, comics, fan fiction, animé/manga, digital stories or "other" through which they had expressed themselves. For reasons that were not immediately apparent, many students chose not to answer the question. An average of 27 participants (40.7%) over all eight categories of mode/modality provided "did not respond," or declined to answer. The number who chose not to respond was higher than any other choice provided for this question (see Figure 2).

Other than "other," the most common chosen response (see Figure 2 for the Stated Top Audiences for Adolescents' Creations), was "everyone else (the public)," chosen in four categories, comics (14, or 21.2%), fan fiction (12, or 18.2%) animé/manga (14, or 21.2%) and digital stories (12, or 18.2%). The second most commonly offered response was "myself only," in three categories, video (11, or 16.7%), music (14, or 21.2%) and photos (13, or 19.7%). See Table 3 in Appendix for details.

Figure 2

The Adolescents' Stated Top Audiences for Their Creations

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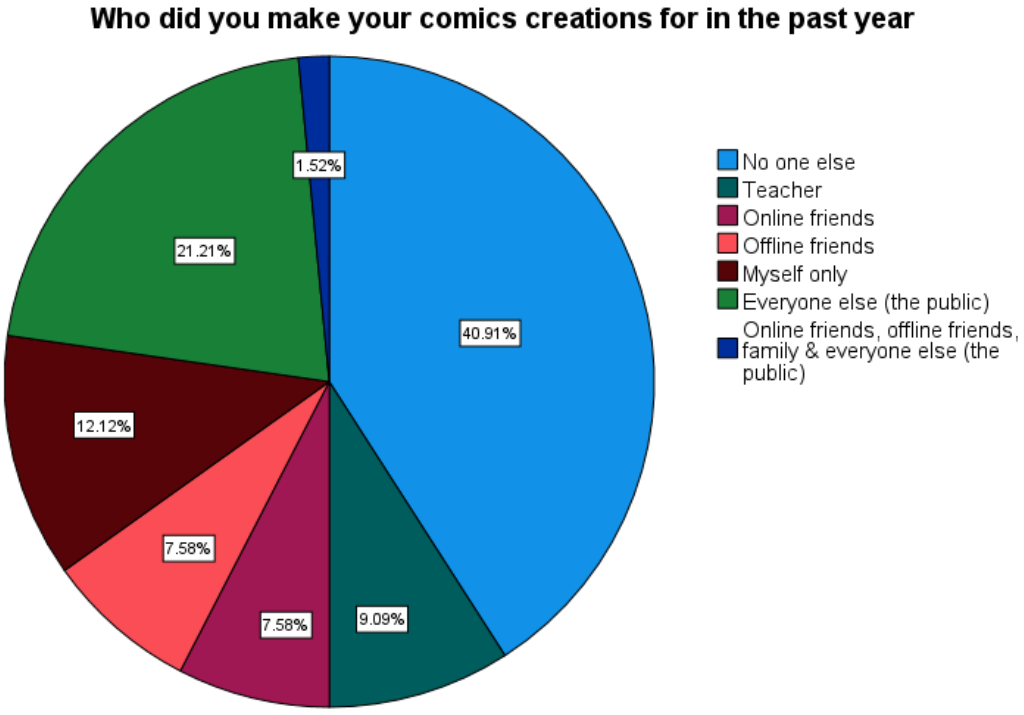

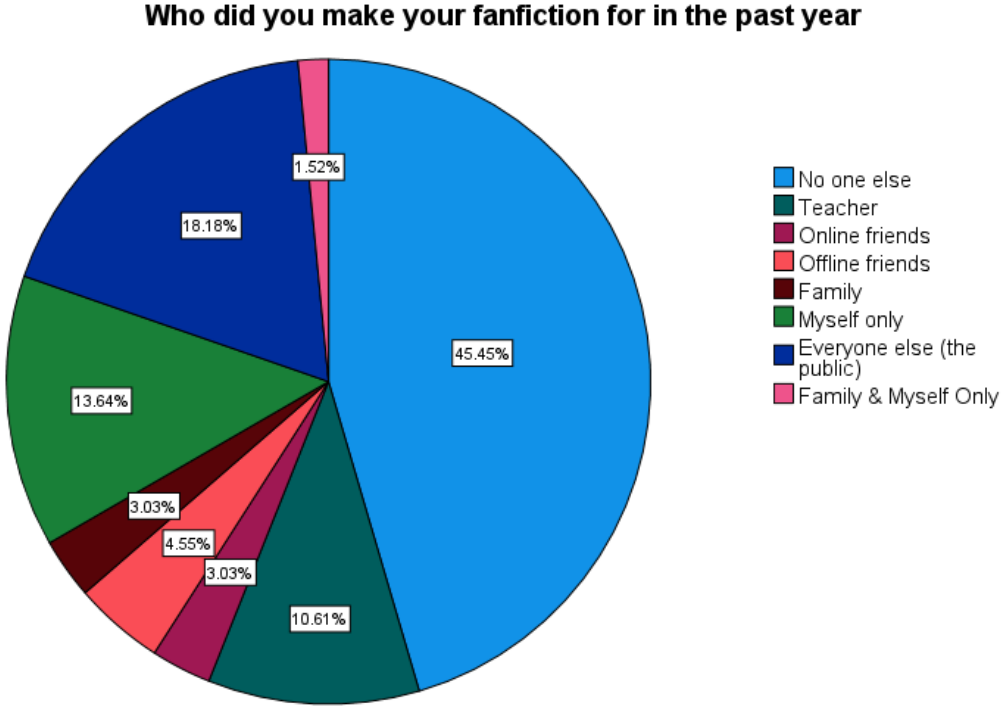

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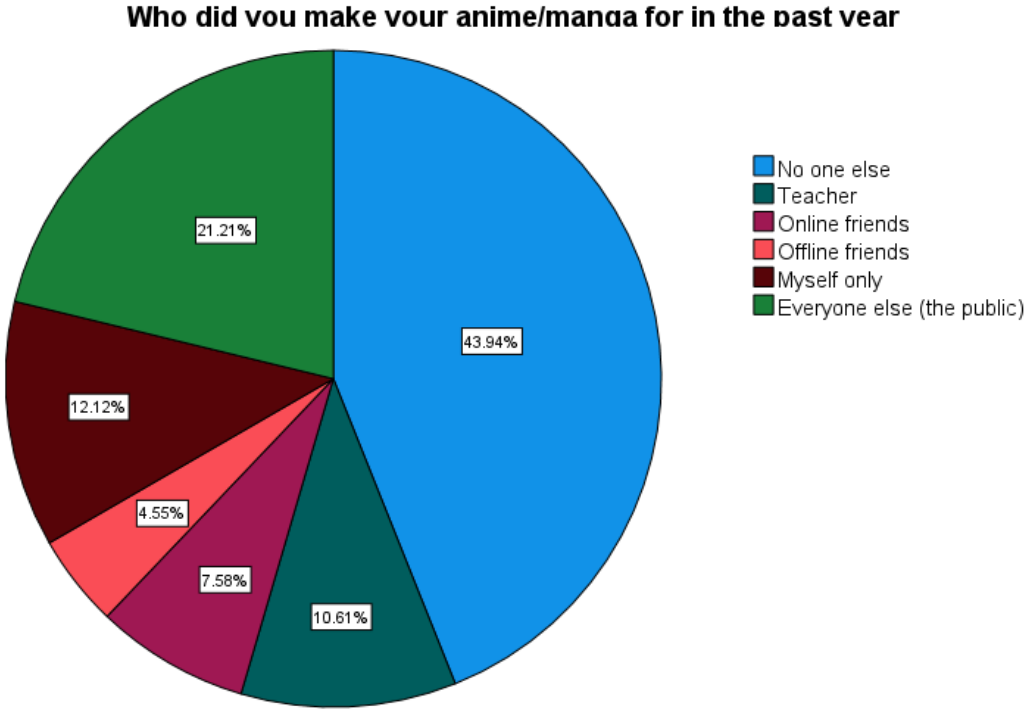

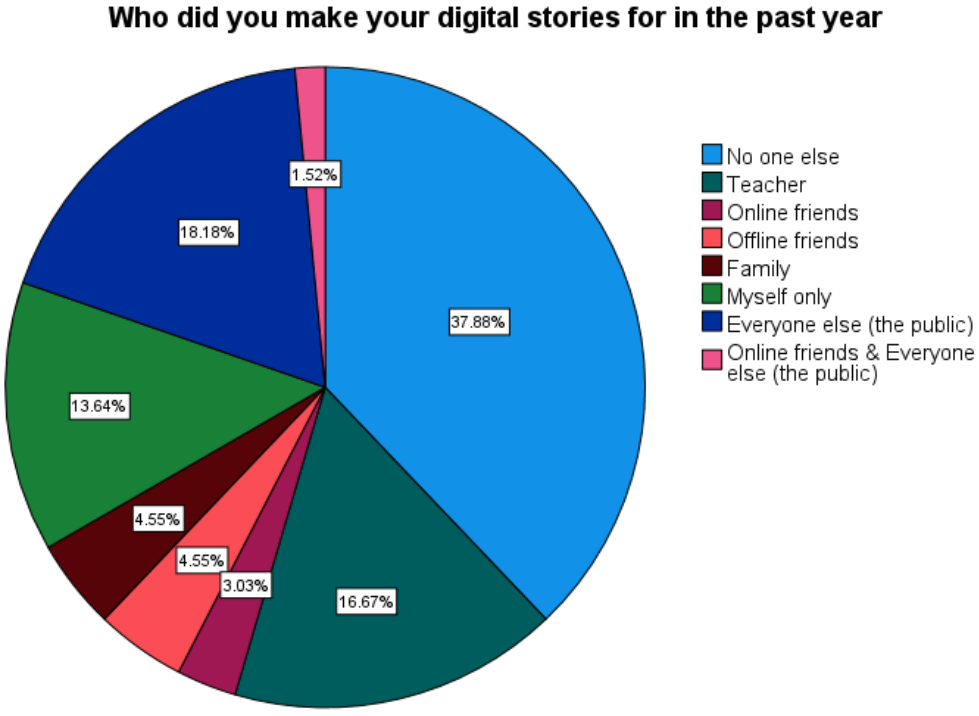

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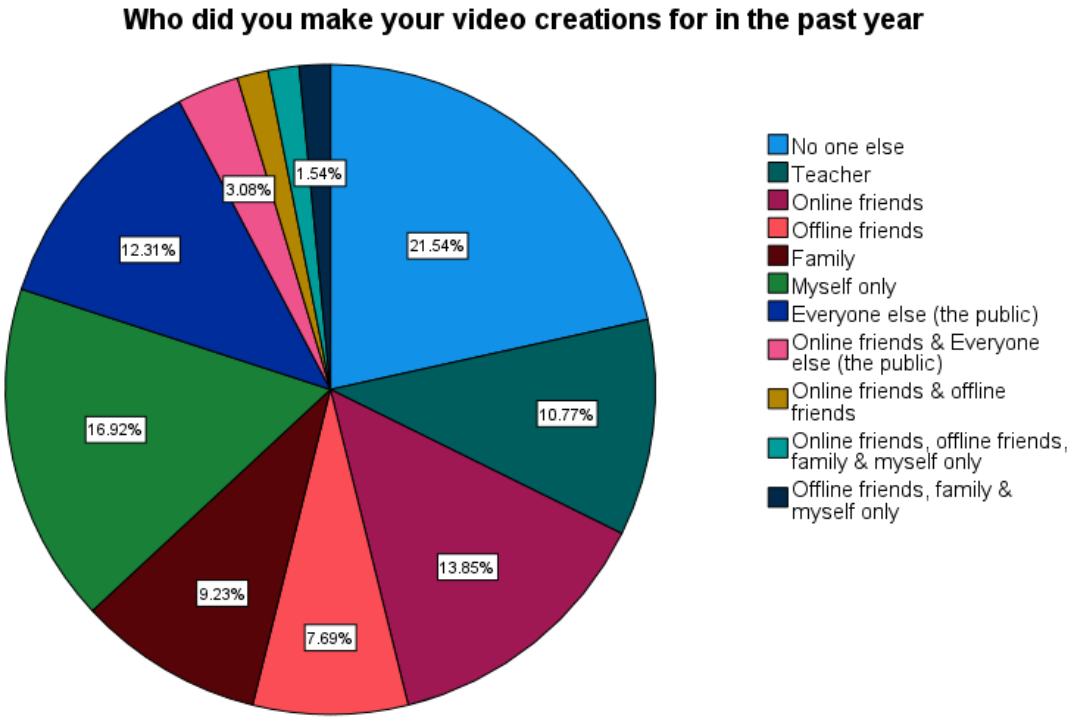

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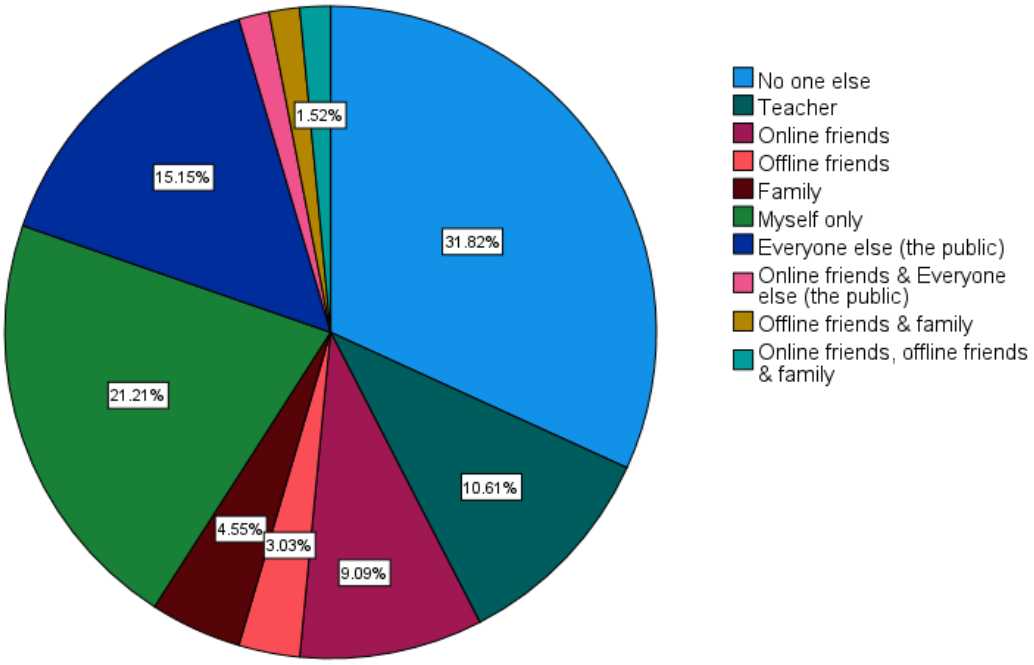
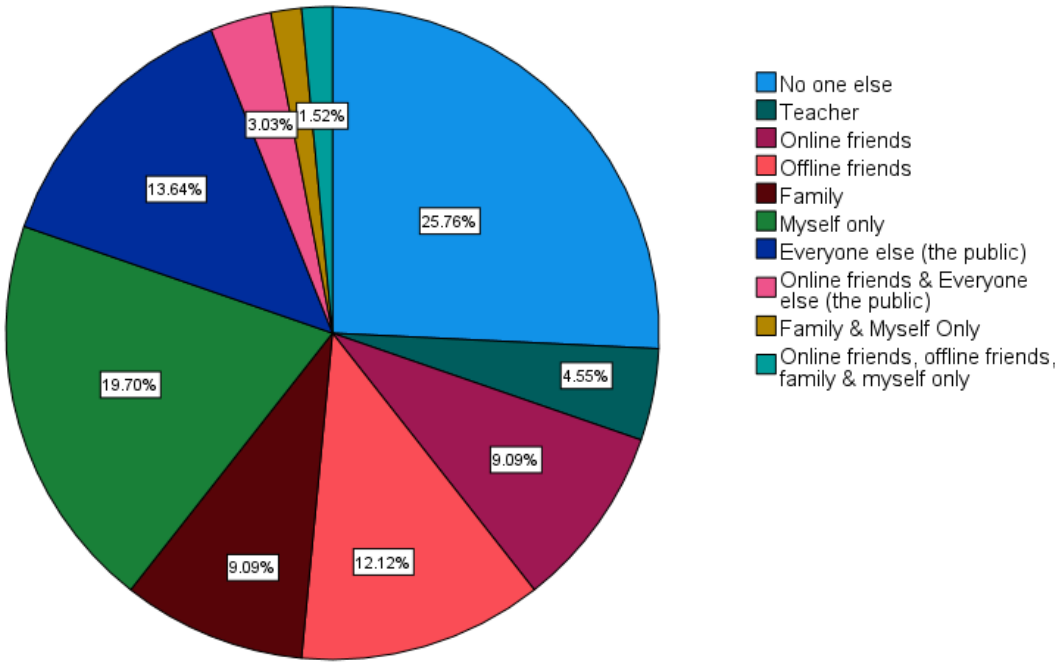
Who did you make your musical creations for in the past year



Who did you make your photo creations for in the past year



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Note. These are responses only from those who chose to respond to the audience question.

The venue. Finally, we wanted to know where the multimodal compositions were distributed and published. We asked this separately for the different modes/modalities of creativity that were available to the students. As above, these were video, music, fan fiction, digital stories, photos, comics, animé/manga and "other." We gave the following options as to where the students' work might be published as a destination: blogs, wikis, websites, Twitter, Facebook/Myspace, Instagram and YouTube. We permitted them to choose multiple categories and we also permitted the response, "did not post." (See Table 4 in Appendix). For fan fiction (26, or 39.4%) made the selection, "did not post." Twenty-six, or 39.4% also made this selection with respect to animé/manga. Forty-four, or 66.7% of those who chose the modality "other," also chose "did not post" (see Figure 3).

Of those who did post, the combination of Instagram and YouTube proved to be the most popular; it was where 21 music participants (31.8%), 24 fan fiction creators (36.4%), 26 digital story writers (39.4%), 16 creators of "other" material (24.2%), 25 comics creators (37.9%), and 26 creators of animé/manga (39.4%) chose to place their work. The second most popular choice was Instagram by itself, which was chosen by 17 video creators (25.8%) and 22 photo creators (33.3%). Much smaller numbers were posted for the combinations Instagram/Snapchat/YouTube, websites/Instagram/ Snapchat/YouTube, and Facebook/Instagram.

Figure 3

The Adolescents' Stated Top Venues for Their Creations

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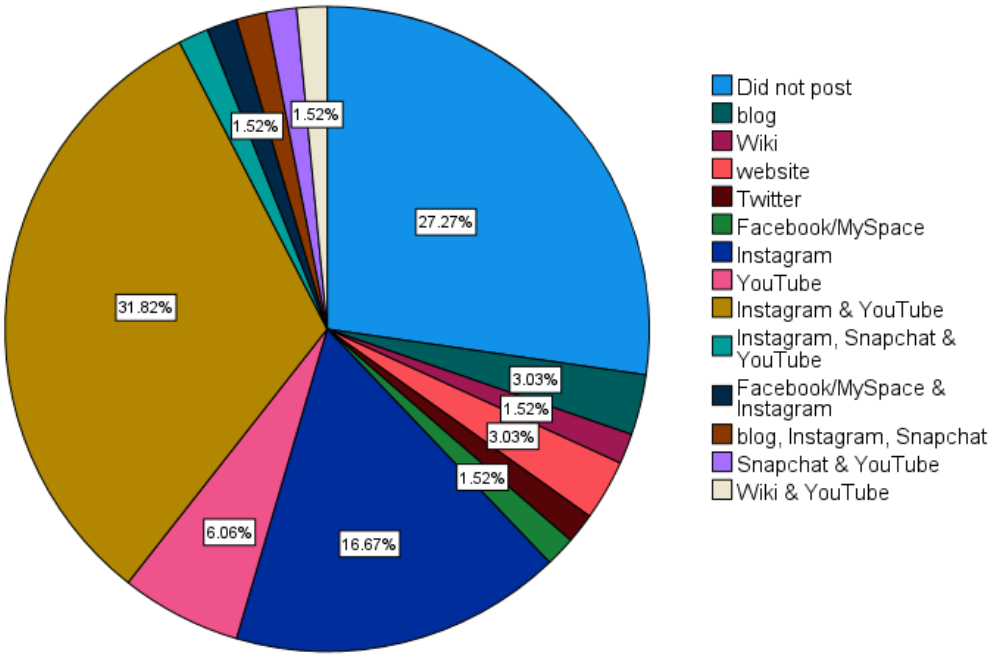
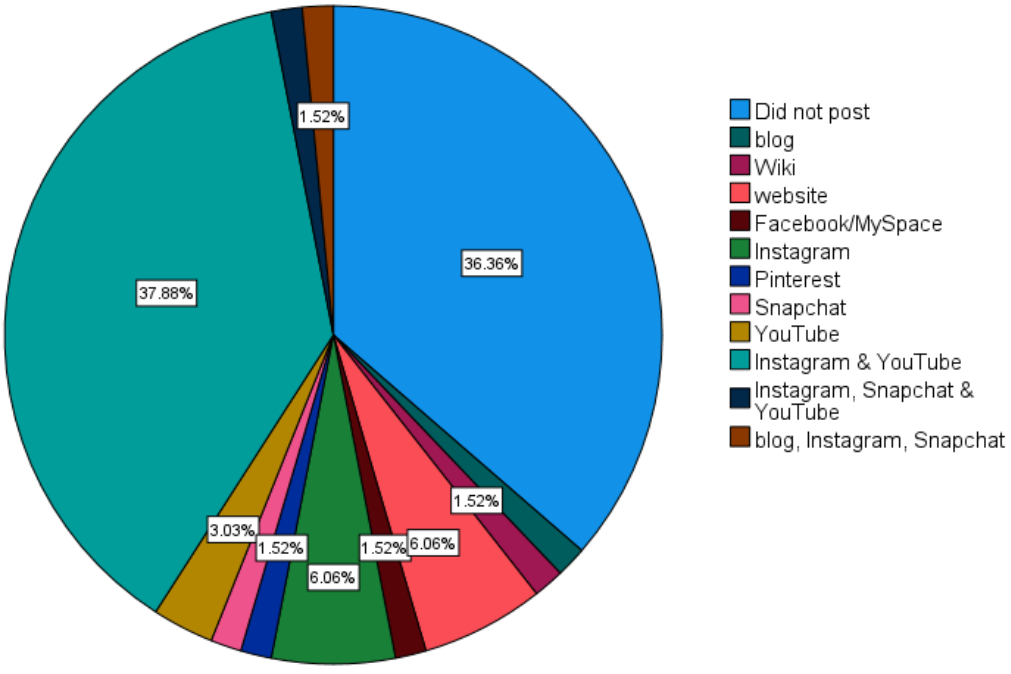
Where did you post any of your musical creations in the past year



Where did you post any of your comics creations in the past year



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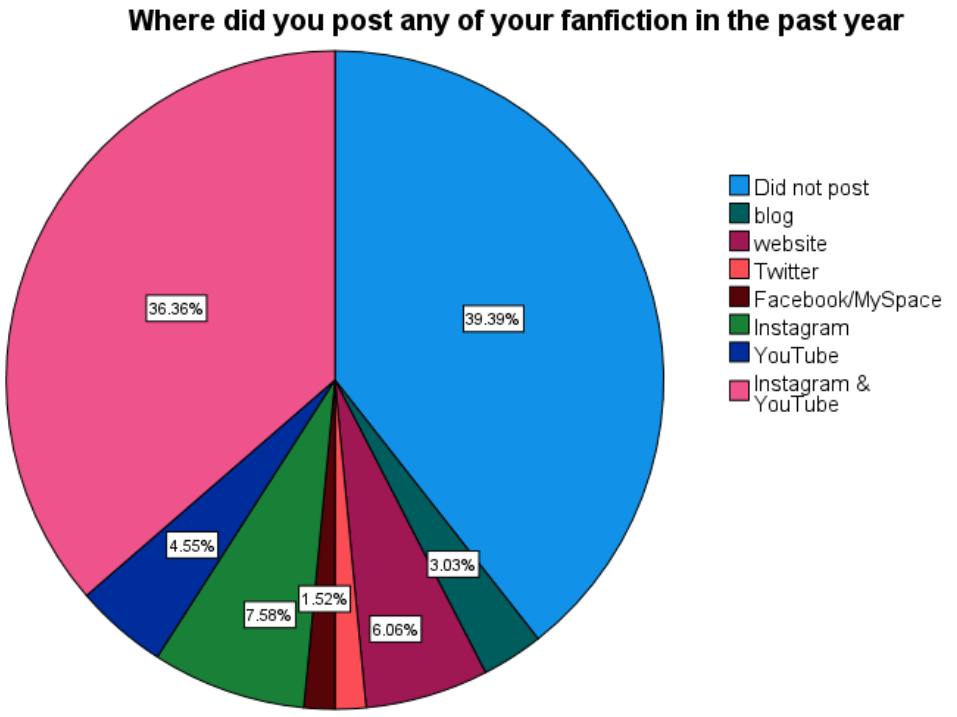

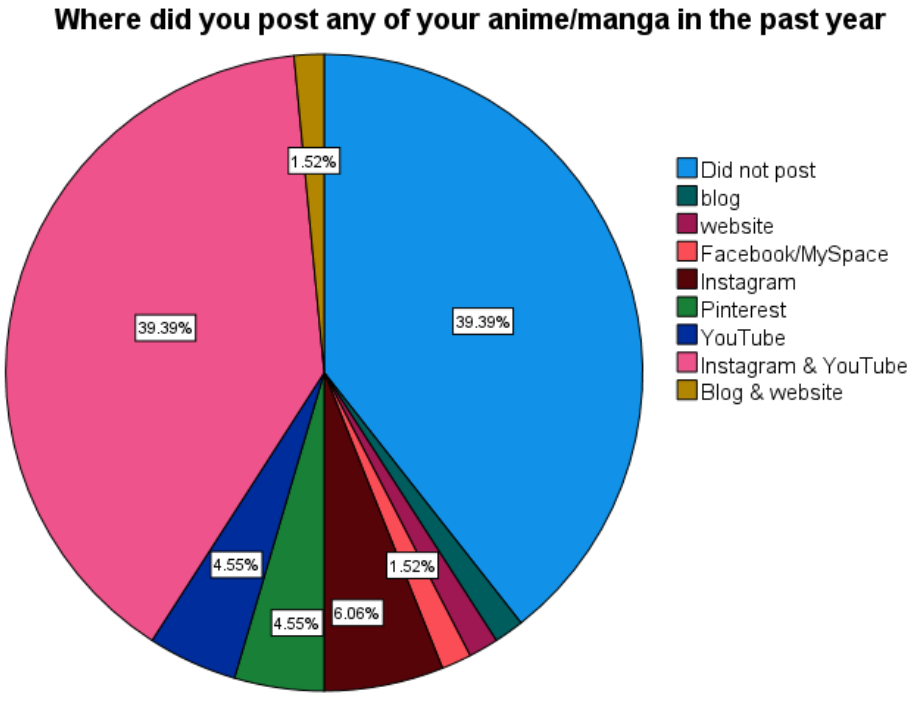

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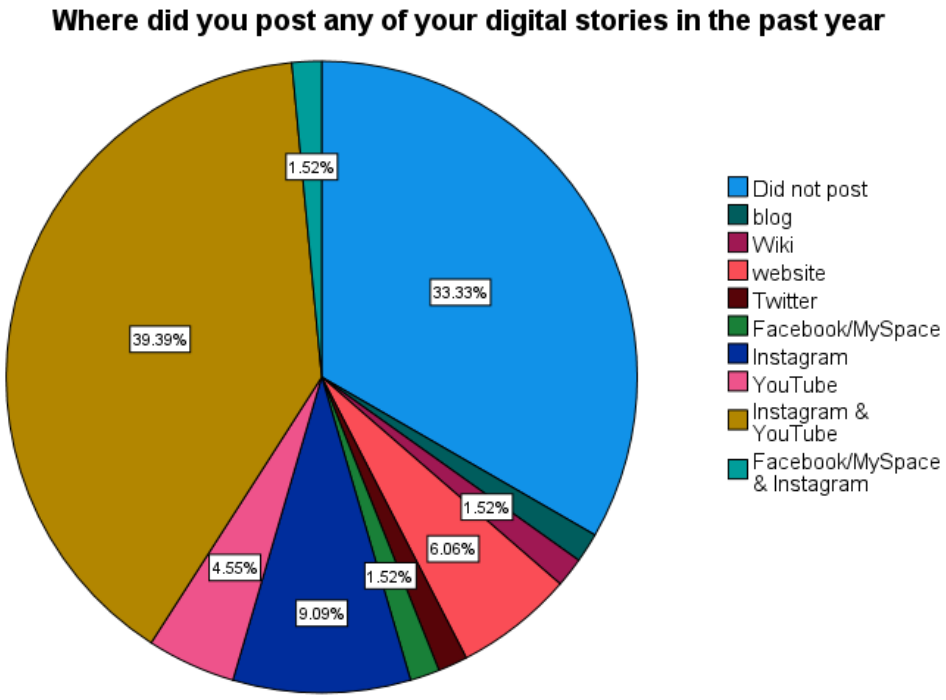

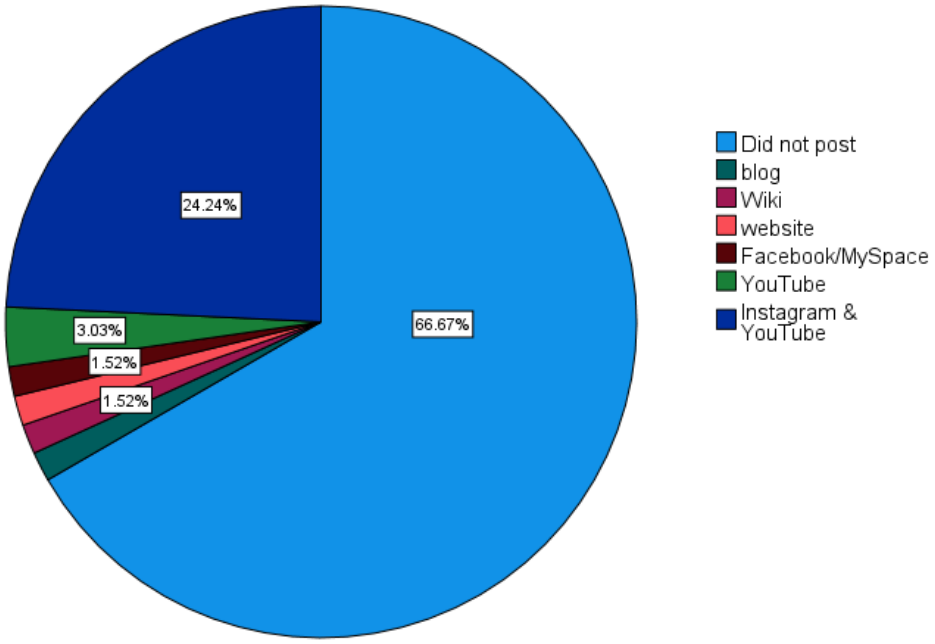

Note. These are responses only from those who chose to respond to the venue question.

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The Value Systems Assigned to Writing and Multimodal Creations (RQ 3)

We approached the evaluation of the ways of using, thinking, and acting upon (Gee, 1989) the "tools and technologies" (Gee, 1990) in young adolescents in a multifaceted way, probing first into the attitudes toward writing in general (from "I hate writing" to "I love writing"), followed by asking young adolescents other affect questions such as how they felt about their multimodal creations (from "very pleased" through "very displeased" and "what they liked the most"), and finally what they learned others thought about their work.

Young adolescents' attitudes toward writing. Concerning the desirability of writing – as that term was understood by the students - we found that, in the 6th grade, among the 15 students reporting, there was relatively little variability among the responses available to the participants. That is, for "I hate writing," 1 participant, or 6.67% responded, for "I dislike writing," 3, or 20% responded, "I kind of dislike writing," captured 2, or 13.33% of respondents; "I kind of like writing," had 3, or 20% of respondents; "I like writing," gathered 2, or 13.33% of respondents; and "I love writing" had 4, or 26.67%of respondents. However, in the 7th grade, 10 out of 29 students (34.5%) reported that they "kind of liked writing;" 8 (12%) reported that they "like" writing, and 5 (7.6%) that they "love" writing. In the eighth grade, four (6%) reported that they "hate" writing, two (3%) that they "dislike" it, four (6%) that they "kind of like" writing, two that they "like" writing and 10 (15%) that they "love" writing.

Overall, 12 of 30 boys said they "kind of liked" writing, six said they "liked" it, and three that they "loved" it. Only five of 36 girls said they "kind of liked" writing, six said they "liked" it but 16 said they "loved" writing.

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Young adolescents' evaluation of creative pieces. Overall, students reported that they were "somewhat pleased" with their own work, never evaluating it poorly for any of the modalities asked about (video, musical, photo, comics, fan fiction, animé/manga, digital story and "other") (see Table 5 in Appendix). Video creations received a mean score of 3.98, just under the response of "somewhat pleased"; music creations received a mean score of 3.92, below, but also close to the response "somewhat pleased,"; photo creations received a mean score of 4.02, just above "somewhat pleased"; comics creations produced a slightly lower mean score of 3.80, below "somewhat pleased"; fan fiction creations produced the lowest mean score of 3.18, just above the midlevel "neither pleased nor displeased"; animé/manga creations produced the score of 3.77, closer to a "somewhat pleased" than "neither pleased nor displeased"; digital stories received a mean of 3.92, just under "somewhat pleased"; and students declined to respond regarding the "other" category, preventing us from drawing a conclusion there.

The second point of evaluation was which characteristic(s) students liked the most about their pieces. The students could choose *none*, *visual impact, ideas/message, structure/design, audience comments, technical skill* or any combination of these. However, in every creative mode inquired into – video, music, photos, comics, fan fiction, animé/manga, and "other creative pieces" – the choice *none* was either a plurality or majority of the choices provided (see Table 6 in Appendix).

Specifically, from our *n* of 66, the number who wrote "none" ranged from 21 for video creations, to 34 for animé/manga and to 49 for "other" creative pieces. Beyond *none*, no other value was found to be present in as high a proportion for each modality. Interestingly, of those who did

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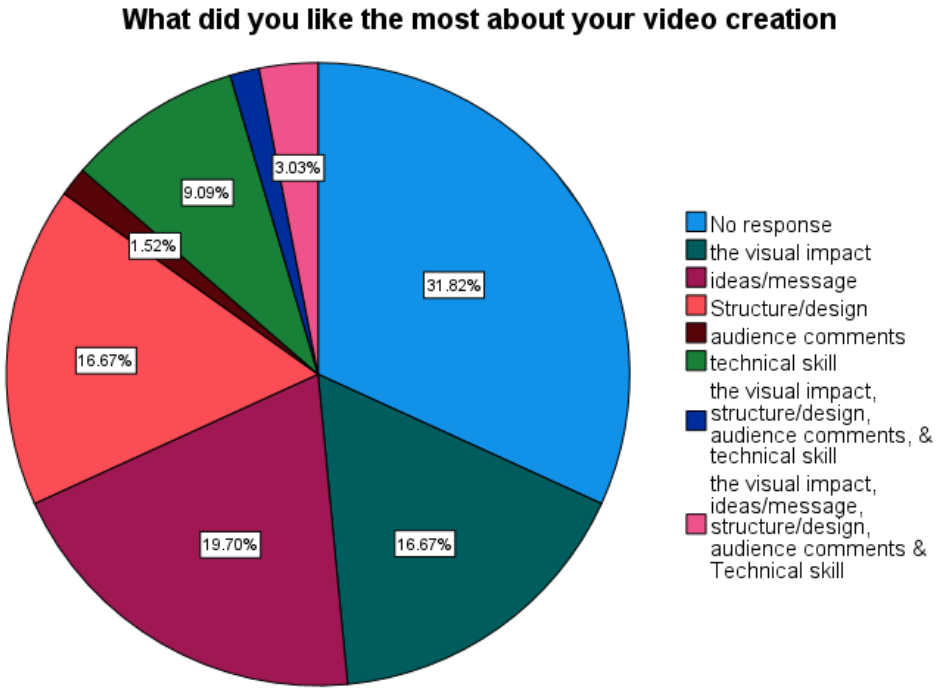
choose a characteristic, in the modality of video, *ideas/message* dominated, with 13 choosing this, and in music, *ideas/message* also dominated, with 15 selectors. *Visual impact* dominated in photo creation, with 12 choosing this; and 10 chose *structure/design* in comics creation. In fan fiction, 10 chose *ideas/message* and in animé/manga, nine chose it. In digital story, however, both *visual impact* and *structure/design* were chosen by nine participants. In the category of other creative pieces, six chose *structure/design* (see Figure 4).

Figure 4

What Adolescents Liked the Most about their Creations



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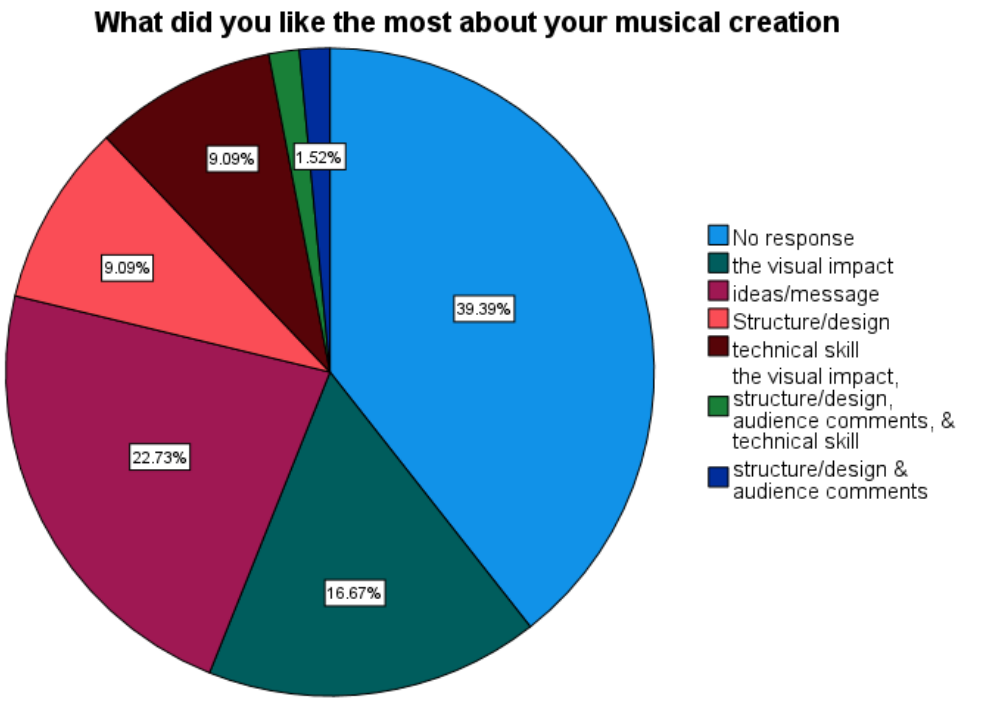

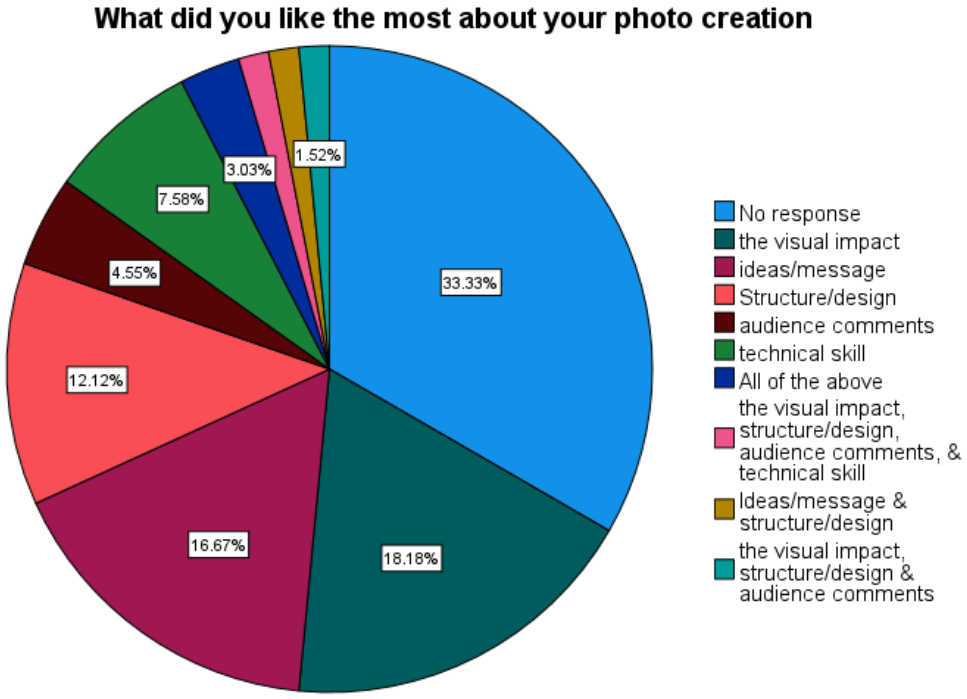

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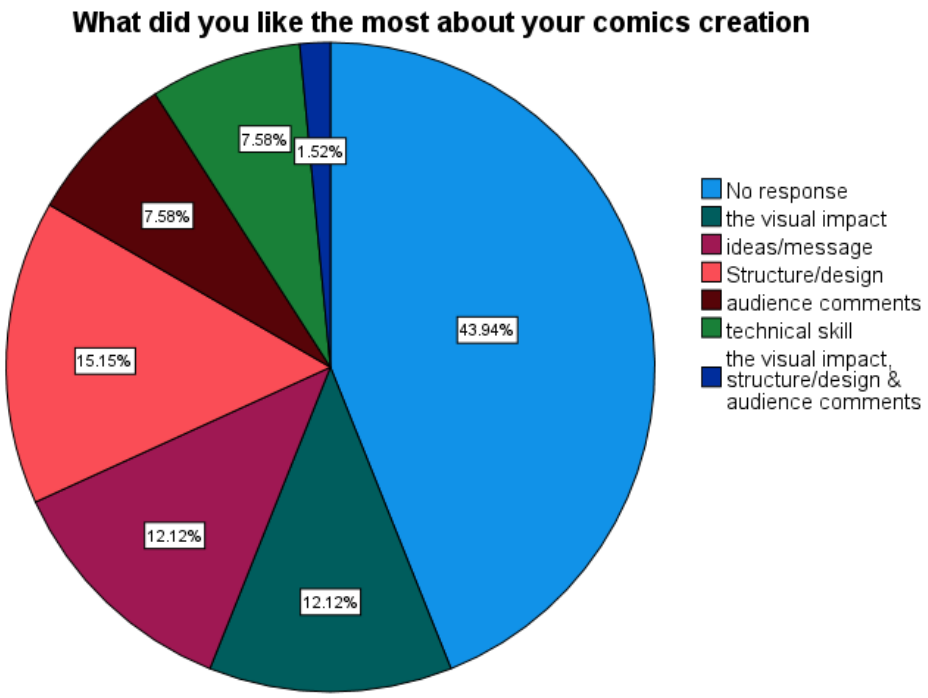

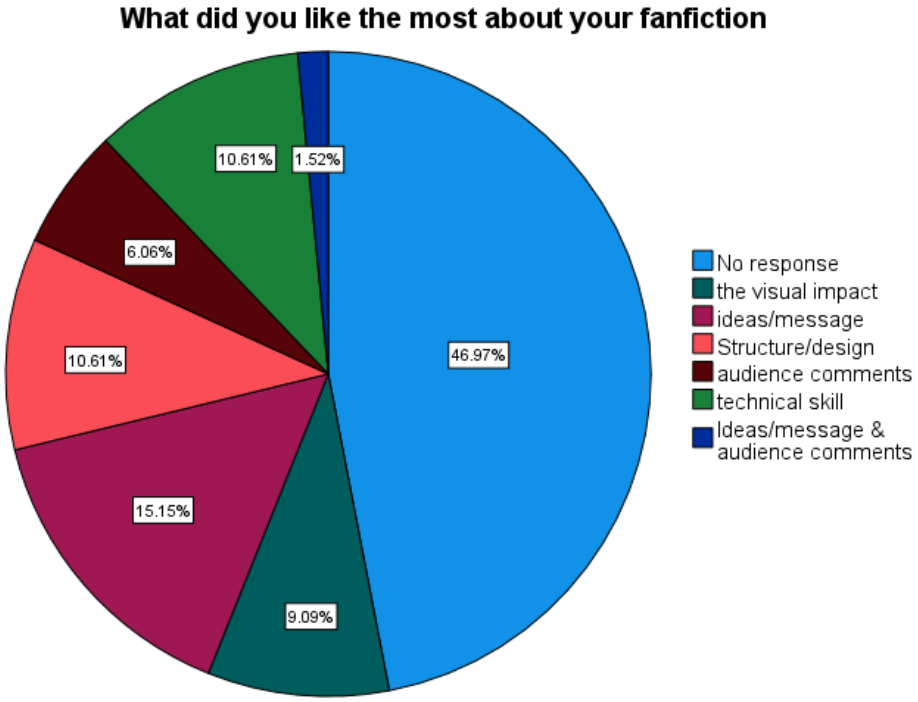

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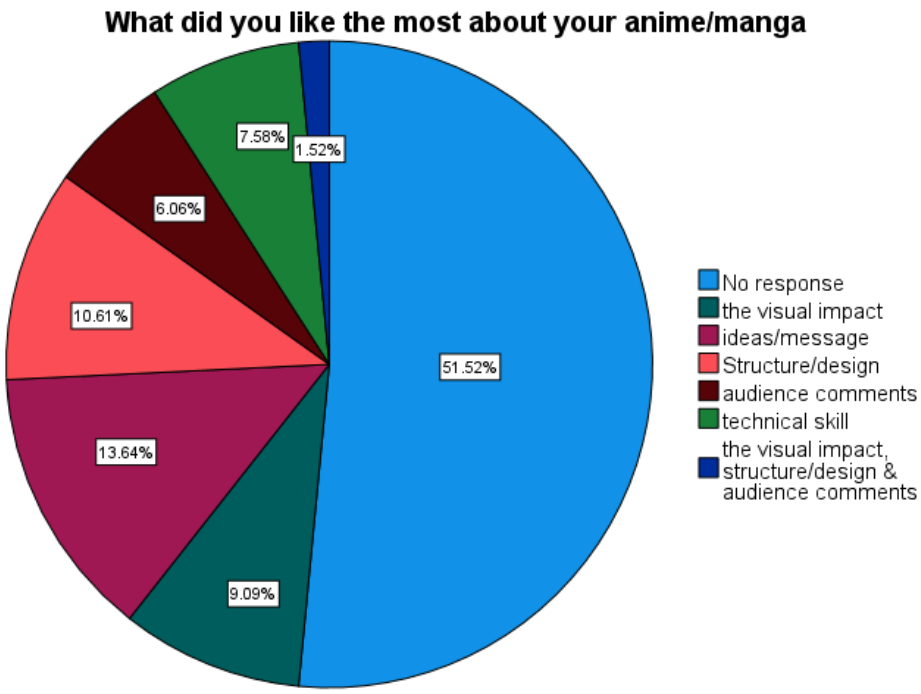

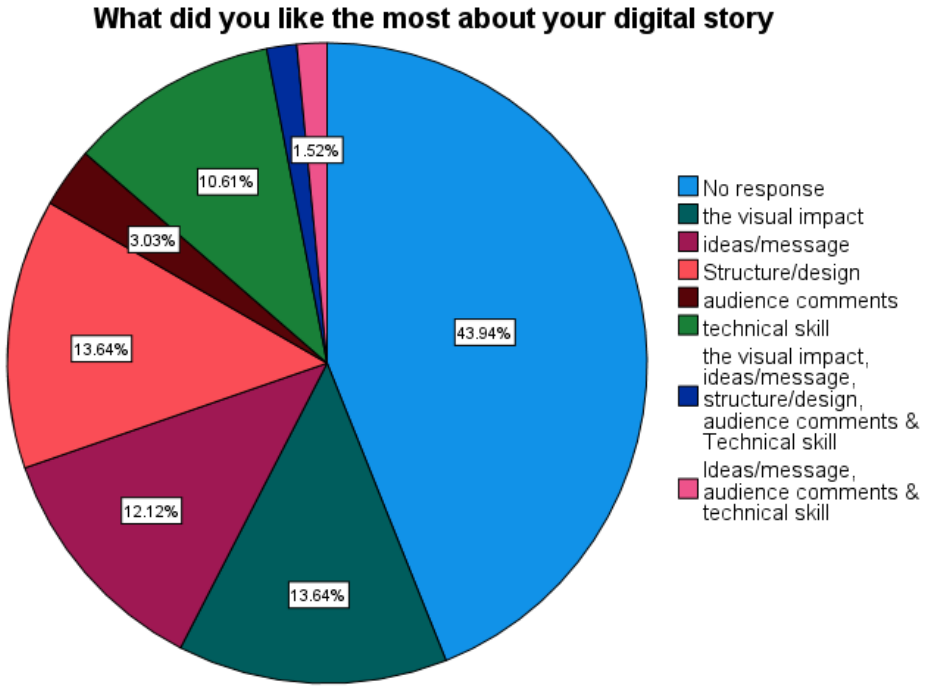

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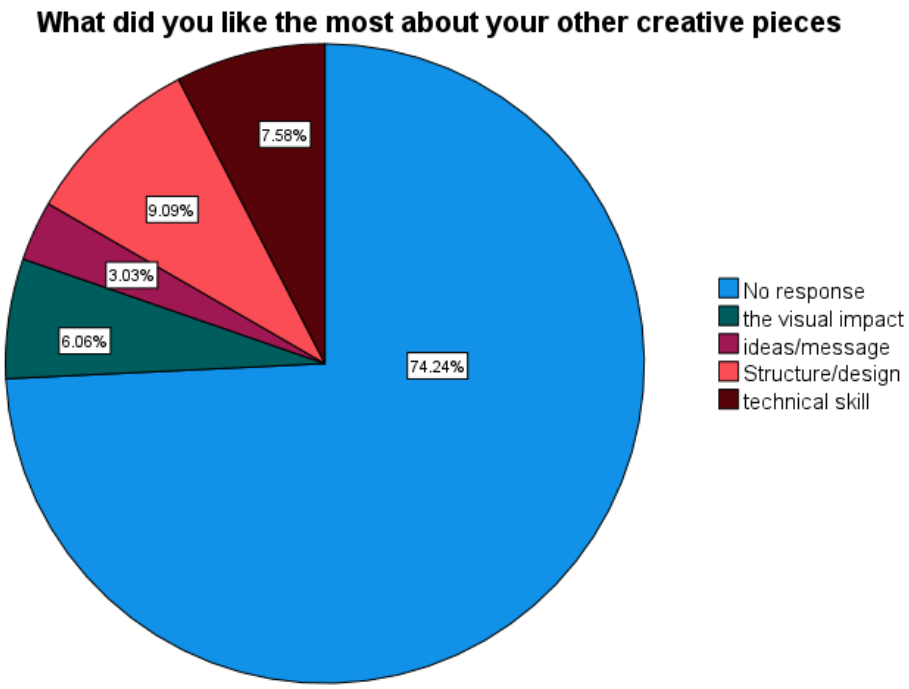

Others' evaluation of young adolescents' creative pieces. The third point of evaluation was which characteristic(s) the creators felt other people liked. The choices were identical to those for self-evaluation, i.e., *none*, *visual impact, ideas/message, structure/design, audience comments, technical skill* or any combination of these. Similar to the second point of evaluation, the option "none" was chosen in a plurality of cases except with respect to "other creative pieces, where it was chosen a majority of the time (51 times, or in 77.27% of cases) (see Table 7 in Appendix).

Discounting the choice of *none* for each of the following types, then, in video creations, the students surmised that others liked the *visual impact* most often, in 15, or 22.73% of cases. In music creations, students chose *ideas/message* most often, in 14, or 21.21% of the time. In photo

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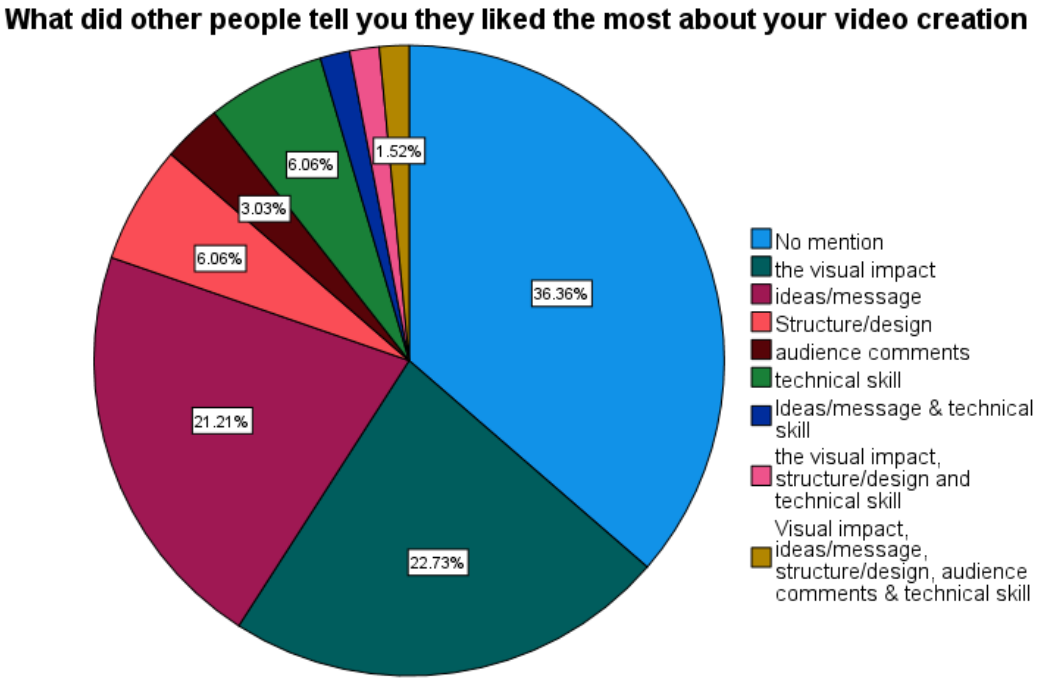
creations, the students chose *visual impact* most often, in 14, or 21.21% of the time, and in comics creations, *visual impact* was also chosen most often, in 12, or 18.18% of cases. In animé/manga, *ideas/message* was chosen most often, in 13, or 19.70% of the time, and in fan fiction, *ideas/message* was also chosen most often, in 14 cases, or 21.21% of the time. In digital stories, students chose *ideas/message* in 14 cases, or 21.21% of the time, and in other creative pieces, they chose *ideas/message* in 4, or 6.06% of the time (see Figure 5).

Figure 5

What Others Liked the Most about Adolescents' Creations



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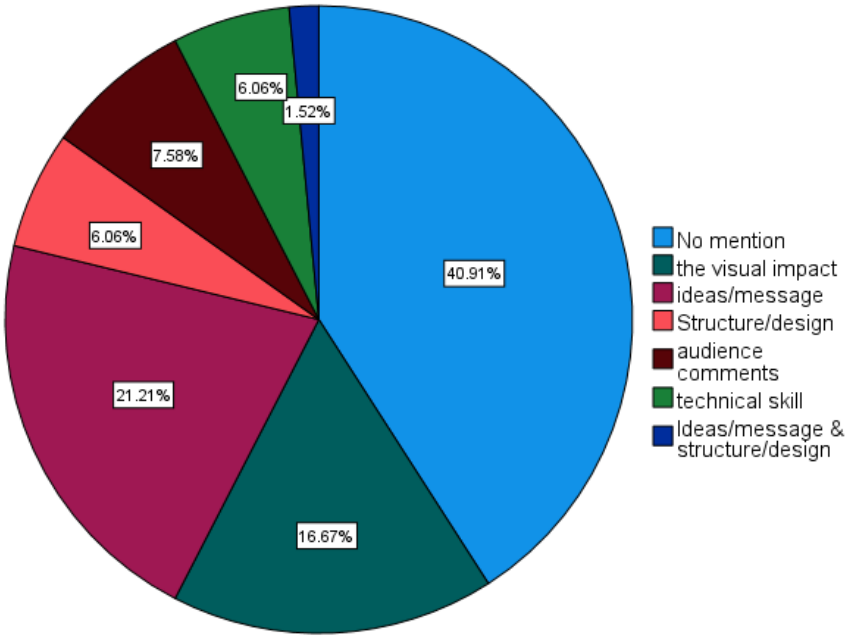
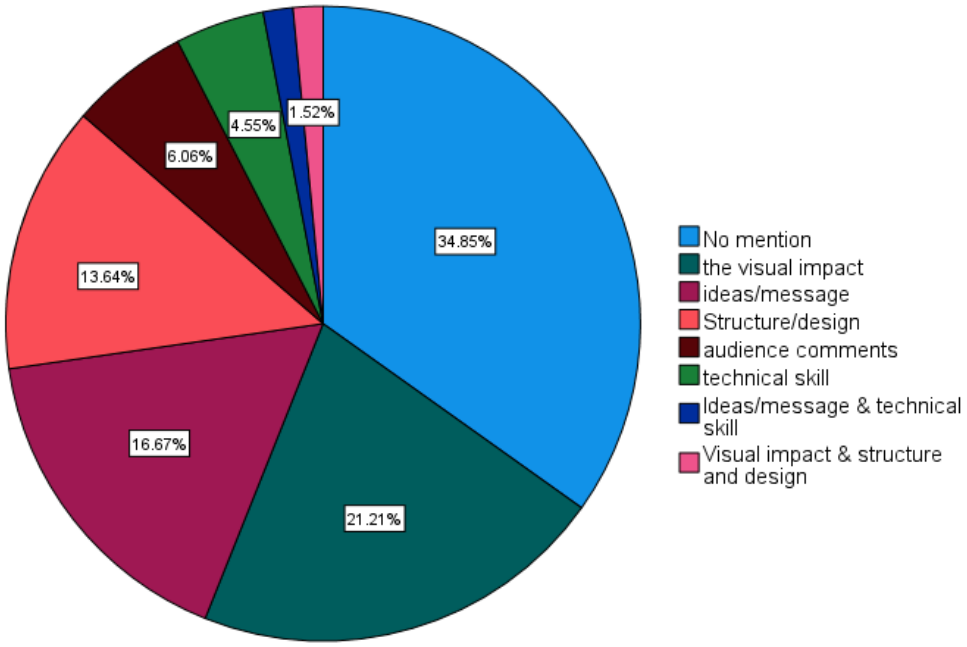
What did other people tell you they liked the most about your musical creation



What did other people tell you they liked the most about your photo creation



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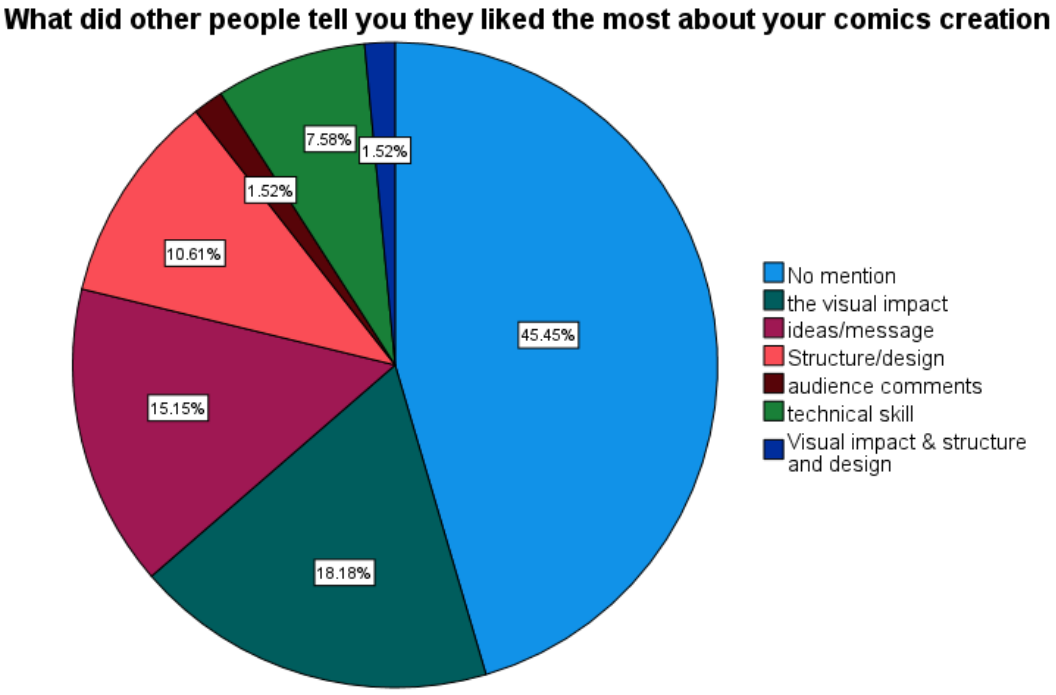

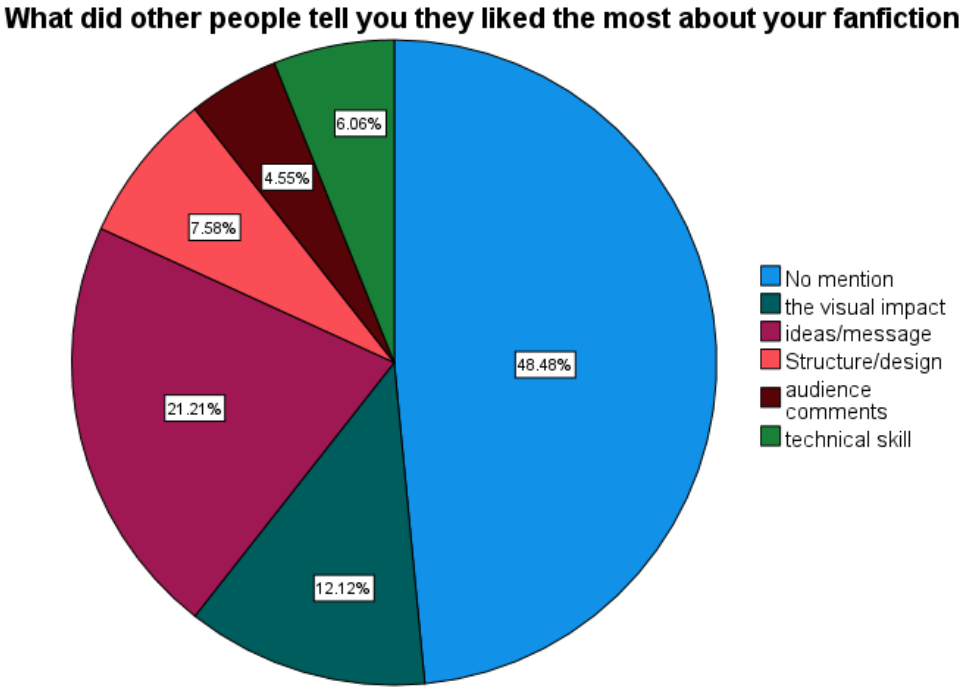

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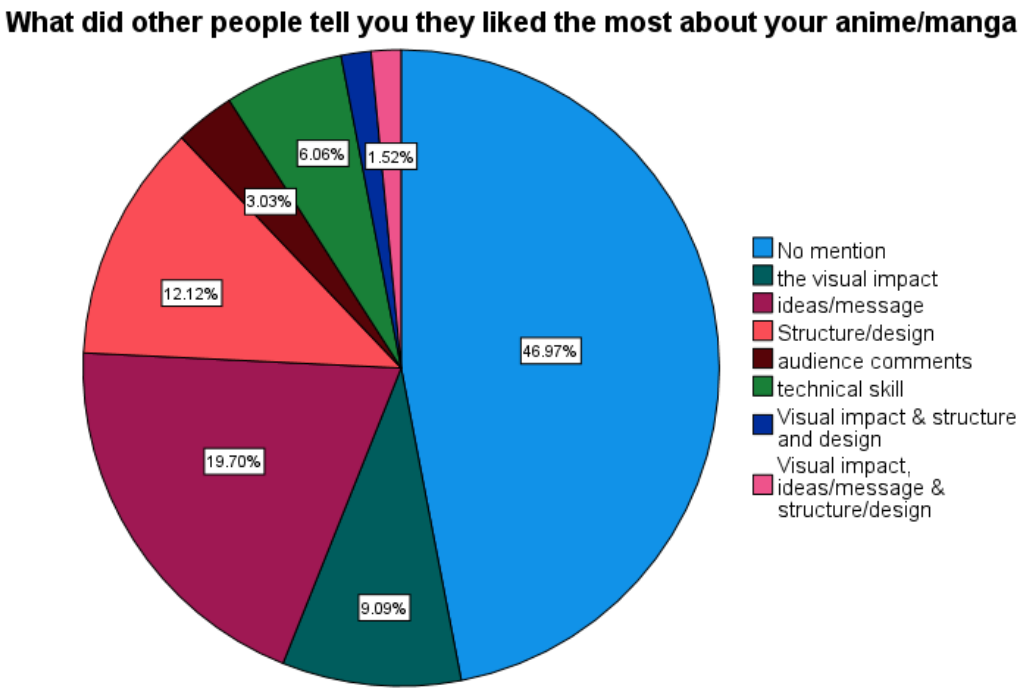

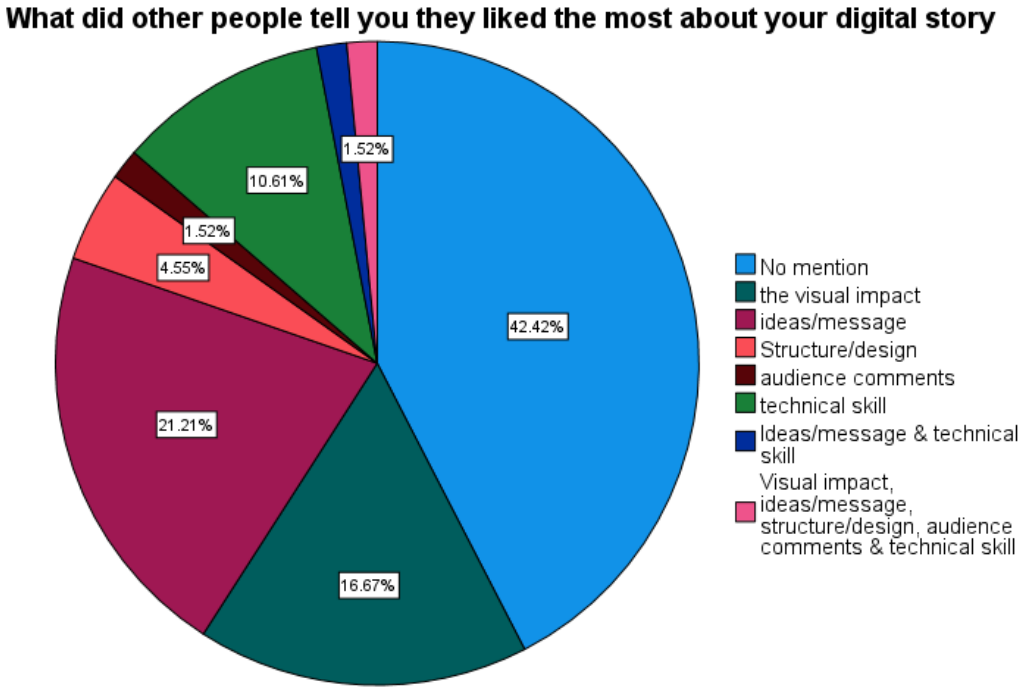

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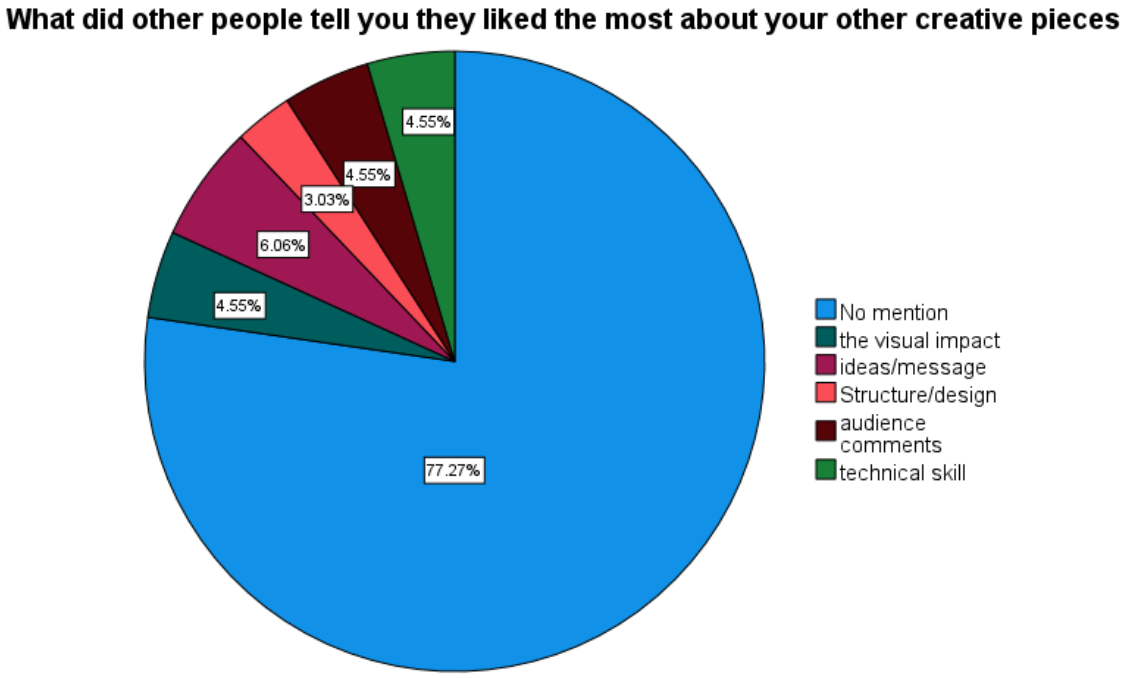

Discussion

The Forms of Multimodal Creations

Voss (2018), writing about the digital multimodal classroom, notes that "[w]here digital literacy learning opportunities in collaborative projects are concerned, unequal opportunities mirror what Henry Jenkins and other scholars in communication and sociology call the digital participation gap" (Voss, 2018, p. 59). We did find some evidence of what Voss (2018) described among our overwhelmingly Black young multimodal composition creators. As we discussed in our findings earlier, according to our survey, those who tended to create one kind of composition said they chose to create in other genres. We found that students who most

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frequently created videos said they tended to create photos, comics, music, and even animé and manga. Moreover, comics creators said they tended to create fan fiction and music. This suggests that these young adolescents work across modalities to make meaning. While this is an encouraging fact on its own, it also means that our research shows that the digitally adept tend to be adept in multiple areas, and to have competencies in several areas of literacy simultaneously. Using Martin and Lambert's (2015) above classification, these are "digital drivers" because of their heavy technology use and creating in "multiple modes and genres" (p. 217).

Also present in the data, however, were certain children who seemed to be left out of the digital multimodal conversation or "digital participation" (Voss, 2018). These are the students who would be closest to "digital passengers," who engage in "minimal digital [multimodal] text creation" (Martin & Lambert, 2015 p. 221). In our study these were the young adolescents who refrained altogether from creating (producing 0 times) complex digital multimodal compositions such as digital stories, animé/manga, fan fiction, and comics. This suggests that many students chose not to make a multimodal creation using a plethora of methods but stuck to the methods they knew. This is problematic because by not engaging in creating these compositions, these young adolescents miss out on an opportunity not only to develop or hone their drawing skills (by hand or digitally), artistic technique (e.g., shading, rendering) and technical skills (i.e., understanding tools and media involved) but also the ability to conceptualize complex plots, to think visually and critically, to communicate wit and humor, and to alphabetically write well, among other, subtler skills (Eisner, 2008). It is to these students that we must direct our attention, as we both assess and seek to most profitably aim the passion, skills and creativity of young

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people in the brave new world of increasingly multimodal composition and communication (Curwood, 2012; Kress, 2003; Morrison, 2010).

Another area that this study explored was how our cohort managed the creation of non-alphabetic texts and what relationship existed between these and traditional alphabetic writing. More than 80% of our young adolescent cohort took at least one photo, and more than 75% had created a video. Almost 30% had taken more than five videos, which is a generally more favorable picture than the one reported pre-pandemic in the national survey of middle school teachers where multimodal creation was infrequent (Graham et al., 2014), in comparison to the data gathered during the pandemic that showed a great deal of media creation among youth in US and abroad (Rideout & Robb, 2021; Martí-Gonzaléz et al., 2020). It is clear that, going forward, both the technological milieu and the thrust of their own expertise are going to make composition with digital affordances a venue for developing creativity skills in addition to more traditional sources of creativity such as painting, dance or diary keeping for young adolescents.

The Purpose, Audience, and Context for Multimodal Creations

In terms of the purpose, the young adolescents chose in majority "for fun" over other categories for the purpose for which they created their multimodal creations. This is understandable and also encouraging since having fun or engagement have been associated with cognitive effort (Miller, 2009), emotional engagement (McClelland & Cameron, 2011), agency (being self-reliant and proactive) in learning (Ivey & Johnston, 2013), and improved writing performance (Graham et al., 2017; Wright et al., 2019). What is disconcerting, however, is the fact the young adolescents did not associate "fun" with "learning" and with "school," because they rarely selected the combination of these values in their survey responses. This finding may

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not be surprising, as according to the national survey of writing in middle school (Ray et al., 2016), the most common forms of writing that teachers reported using in the classroom were writing short responses, note taking, and completing worksheets, at least once a week, while creating a multimodal text such as a PowerPoint occurred "only several times a year" (p. 1056). The same trend was observed in the 2014 national survey of middle school teachers' writing instruction (Graham et al., 2014). The recent data also noted the challenges that the pandemic wrought with reading and writing instruction for young learners (Skar et al, 2023; Rideout et al., 2022). Thus, both the results from this study and previous research indicate a strong need for multimodal composition and multimodal composing instruction (of which more below) in schools such as our research site (an urban title 1 school) on a more regular than an occasional basis.

While good writers know their audience well (Kellogg, 2008) and they understand how to engage it and learn from their perspectives and experiences (Magnifico, 2010), the young adolescents in this study exhibited a relatively poor conception of audience. This was evident where the majority of our young adolescents chose either "everyone else," "oneself" or "no one" in particular as the audience for their multimodal creations, which suggests a very abstract-sounding audience awareness (Litt & Hargittai, 2016) as well as self-centeredness (Blau, 1983). Young writers often struggle with the concept of audience (Barbeiro, 2010) in general, and whereas this study corroborates this trend, it also shows the need for re-examining this concept in "new media-infused learning environments" (Magnifico, 2010, p. 167) such as YouTube, Instagram/Facebook, Snapchat and similar social media platforms where our participants and the participants in previous research were reported to publish and distribute their multimodal

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creations (Anderson & Jiang, 2018; Lenhart, 2015; NORC, 2017). Learning to understand the intricacies of the online audience is a difficult task though as the audience that these young writers may imagine for their posts with multimodal creations may not necessarily be the actual audience (Litt & Hargittai, 2016; McGrail & McGrail, 2014).

Alternatively, the audience composition itself might be widely diverse, including for example family, the general public and peers, with each potentially having different expectations (Litt & Hargittai, 2016; Marwick & boyd, 2010). Young writers will need therefore much help with unpacking the rhetorical contexts within which their audiences exist (Morrison, 2010; Palmeri, 2012), as well as knowing how to address the needs of both general and targeted audiences. More research is definitely needed to better understand the construct of audience on social media platforms among young adolescent multimodal creators, which will provide the insight on which educators can build their future instruction.

Although YouTube, the most popular channel reported for adolescent content creators in previous research (Anderson & Jiang, 2018), was also a popular dissemination venue among the young adolescents in this study, they chose to post their multimodal creations onto both YouTube and Instagram (the second most popular choice), thus expanding the reach and profile for their work, especially for video, music, digital story, and fan fiction. This was not true of all participants, however, as one-third of composers in two genres, (fan fiction and animé/manga) opted not to publish their work at all and more than 50 % did not post “other” creations. The latter groups of young adolescent participants clearly underutilized online spaces available for their multimodal creations, which is in opposition to the trends reported in previous research where about 87% of teens ages, 12-17 use the internet to share their multimodal content with a

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wider audience (Lenhart & Madden, 2005) and where "almost all U.S. teens [97%] report using the internet daily" (Vogels et al., 2022, p.8). The lower self-evaluation ratings in this study for fan fiction (19.70 %), comics (24.24 %), and animé/manga (28.79%) suggest that their creators were not very pleased with, and hence perhaps not comfortable sharing these multimodal creations with others. Alternatively, firewall barriers might have prevented access to social media sites.

The Value Systems Assigned to the Multimodal Creations

The well-known gender distinction in affect towards writing (Fletcher, 2006; Fearrington, et al., 2014) was partially supported in our cohort, as the girls tended to "love" writing more and more as they progressed from 6th through 8th grade while the boys' positive affect for writing seemed to peak in the 7th grade, when they "kind of liked" it. While both girls and boys need a writing-friendly environment to advance their skills, helping boys develop confidence and interest in writing in early middle grades is important. Fletcher (2006) suggests attending to their topic interests, inviting the genres that boys favor (e.g., warfare, dynamic action, bathroom humor) and incorporating play and performance, among other suggestions. Based on the findings in this study, we would like to add to these recommendations video, music, and digital story writing since these multimodal genres were most popular with the young adolescents we surveyed. Additionally, educators should consider likely distinctions for genre and modalities for Black boys and girls, based on culture, learning styles and other background characteristics. For example, Tichavakunda and Tierney (2018) have noted that, not only are certain technologies, such as laptops and tablets less often found among young Black students in comparison to their white peers, but Black students use those technologies somewhat differently, pushing their

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smartphones to do tasks to compensate for perceived deficiencies. Lewis Ellison and Solomon (2018) have also reported race and gender differences in digital play and creativity for the young African American boys they studied. This topic has not been explored extensively and it requires further investigation.

Overall, the creations with which the majority of our young adolescents were "somewhat pleased" included, in descending order, photos, video, music, digital stories, and comics. The young adolescents were the least satisfied with animé/manga creations. These findings align with the levels of comfort that the young adolescents had with using the tools and applications for generating the latter genres. Specifically, in the majority, the comfort levels with video and audio editing applications were ranked 6 and 7, respectively, while the ratings for the comics and animé/manga technologies were below the top rankings. These findings suggest that either these young adolescents have high expectations for their creative work, especially for animé/manga, or that their technical and composing skills in these genres need improvement.

The young adolescents' evaluation of specific aspects of multimodal writing craft was most perplexing, because in the majority they indicated "none" from the evaluation characteristics provided (e.g., visual impact or ideas/message). This could mean that either they thought that certain creations were not strong enough (see the comments above about being only "somewhat pleased" with a number of genres) or that they might have not understood well the concepts the evaluation criteria addressed. A similar lack of response existed for the question of how they perceived what other people liked about their creations.

The trends in the self-evaluation of multimodal creations reported in here reflect a well-documented long-term struggle with evaluating multimodal composition in the field at large

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(Curwood, 2012; Kalantzis et al., 2003). For example, after reviewing the frameworks for evaluating multimodal composition in K-12 contexts, the first author of this article and a colleague (McGrail & Behizadeh, 2017) found that educators often used the frameworks and assessments for traditional writing (print-based texts), rather than assessments tailored to assess multimodal writing and design (e.g., visual impact or text structure in fan fiction). If we wish young creators to be able to critically and meaningfully evaluate their multimodal designs, they and their teachers need a better understanding of what such designs involve and how to assess the unique aspects and conventions of particular multimodal genres (e.g., digital story, musical or photographic composition, comics, animé/manga).

Conclusion

Insights gleaned from this exploration shed light on how young adolescent writers in one urban school context utilized the technologies and applications available to them for meaning making and the degree to which their creations were "distributed, interpreted, and remade through many representational and communicational resources, of which language is but one" (Jewitt, 2008, p. 246). While overall the findings indicate some degree of diversity of form, purpose, and audience in composing in the classroom and beyond among young adolescent writers who have limited technology resources, these findings also reveal gaps in this particular educational setting in certain modalities for some groups of young adolescents. They also call attention to the need to help these young creators with developing an audience awareness, especially of an online audience, and assessing specific aspects of their multimodal creations.

It is gratifying, of course, that we have mostly emerged from the isolation brought about by the pandemic. It had strong and measurable effects on the learning students were able to

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accomplish (Skar et al., 2023; Rideout et al., 2022), and doubtless, much more research will assess if and where they flourished during their 18-month privation. In the meantime, while we note that other research has shown that it did not expunge the flame of students' digital multimodal creations in their many formats and forms (Rideout & Robb, 2021; Martí-Gonzaléz et al., 2020), further research is needed to find if newer digital social media create entirely different audiences for adolescents to acknowledge, address and create for. We look forward to creating new research, modeled on what is reported here, that assesses anew how students creatively grapple with ever newer digital tools.

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APPENDIX

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Table 1 *Reported Number of Times Multimodal Creation Type Produced (n=66)*

Multimodal Creation Type	0 Times		1-2 Times		3-4 Times		5 or More Times		Total	Total
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	No.	Percent
Photos	12	18.2	13	19.7	11	16.7	30	45.5	***54***	***81.8%***
Video	16	24.2	23	34.8	8	12.1	19	28.8	***50***	***75.8%***
Music	19	28.8	17	25.8	15	22.7	15	22.7	***47***	***71.2%***
Digital Story	35	53.0	8	12.1	11	16.7	12	18.2	31	47%
Comics	38	57.6	16	24.2	6	9.1	6	9.1	28	42.4%
FanFiction	41	62.1	8	12.1	10	15.2	7	10.6	25	37.9%
Anime/Manga	43	65.2	12	18.2	7	10.6	4	6.1	23	34.8%
Other	63	95.5	0	0	1	1.5	2	3.0	3	5%

Note: The top three total multimodal types have been italicized and bolded.

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Table 2 *Stated Purposes for Multimodal Compositions(n=66)*

Multimodal Type	Frequency	Percent	(Cumu.) Percent	Multimodal Type	Frequency	Percent	(Cumu.) Percent
Video				**FanFiction**			
None	15	22.73	22.73	None	30	45.45	45.45
For school	5	7.58	30.30	For school	4	6.06	51.52
For fun	34	51.52	81.82	For fun	22	33.33	84.85
To learn	1	1.52	83.33	To learn	4	6.06	90.91
To be part of a group	6	9.09	92.42	To be part of a group	6	9.09	100.00
For fun & to learn	2	3.03	95.45	Total	100.0	100.0	
For school & for fun	2	3.03	98.48	**Anime/Manga**			
For school & to learn	1	1.52	100.00	None	29	43.94	43.94
Total	100.00	100.00		For school	4	6.06	50.00
Photo				For fun	22	33.33	83.33
None	16	24.24	24.24	To learn	5	7.58	90.91
For school	4	6.06	30.30	To be part of a group	6	9.09	100.00
For fun	36	54.55	84.85	Total	100.0	100.0	
To learn	3	4.55	89.39	**Digital Story**			
To be part of a group	5	7.58	96.97	None	28	42.42	42.42
For fun & to learn	1	1.52	98.48	For school	5	7.58	50.00

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For school & for fun	1	1.52	100.00	For fun	17	25.76	75.76
Total	100.0	100.0		To learn	6	9.09	84.85
Music				To be part of a group	7	10.61	95.45
None	20	30.30	30.30	For fun & to learn	1	1.52	96.97
For school	2	3.03	33.33	For school & for fun	1	1.52	98.48
For fun	31	46.97	80.30	For school and to learn	1	1.52	100.00
To learn	4	6.06	86.36	Total	100.0	100.0	
To be part of a group	7	10.61	96.97	**Other**			
for fun & to be part of a group	1	1.52	98.48	None	51	77.27	77.27
For fun & to learn	1	1.52	100.00	For school	1	1.52	78.79
Total	100.0	100.0		For fun	6	9.09	87.88
Comics				To learn	1	1.52	89.39
None	27	40.91	40.91	To be part of a group	7	10.61	100.00
For school	3	4.55	45.45	Total	100.0	100.0	
For fun	25	37.88	83.33				
To learn	4	6.06	89.39				
To be part of a group	7	10.61	100.00				
Total	100.0	100.0					

Note. While every category of composition featured the same suggested reasons (“for fun,” “for school,” etc.) from which the participants could choose, some of these reasons ended up not being selected at all, and hence the categories chosen by 0 students were omitted from this table.

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Table 3 *Stated Audiences for Multimodal Compositions*

Multimodal Type	Did not respond	Teachers	Online friends	Offline friends	Family	Myself only	Everyone else (the public)
Video							
Frequency	14	7	9	5	6	11	8
Percent	**21.2**	10.6	13.6	7.6	9.1	***16.7***	12.1
Cumu. Percent	21.2	31.8	45.5	53.0	62.1	78.8	90.9
Music							
Frequency	21	7	6	2	3	14	10
Percent	**31.8**	10.6	9.1	3.0	4.5	***21.2***	15.2
Cumu. Percent	31.8	42.4	51.5	54.5	59.1	80.3	95.5
Photos							
Frequency	17	3	6	8	6	13	9
Percent	**25.8**	4.5	9.1	12.1	9.1	***19.7***	13.6
Cumu. Percent	25.8	30.3	39.4	51.5	60.6	80.3	93.9
Comics							
Frequency	27	6	5	5	0	8	14
Percent	**40.9**	9.1	7.6	7.6	0	12.1	***21.2***
Cumu. Percent	40.9	50.0	57.6	65.2	0	77.3	98.5
Fanfiction							
Frequency	30	7	2	3	2	9	12

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Percent	**45.5**	10.6	3.0	4.5	3.0	13.6	***18.2***
Cumu.Percent	45.5	56.1	59.1	63.6	66.7	80.3	98.5
Anime/Manga							
Frequency	29	7	5	3	0	8	14
Percent	**43.9**	10.6	7.6	4.5	0	12.1	***21.2***
Cumu. Percent	43.9	54.5	62.1	66.7	0	78.8	100.0
Digital Story							
Frequency	25	11	2	3	3	9	12
Percent	**37.9**	16.7	3.0	4.5	4.5	13.6	***18.2***
Cumulative Percent	37.9	54.5	57.6	62.1	66.7	80.3	98.5
Other							
Frequency	52	2	0	2	1	2	7
Percent	**78.8**	3.0	0	3.0	1.5	3.0	***10.6***
Cumu. Percent	78.8	81.8	0	84.8	86.4	89.4	100.0

Note: We also exhaustively asked about every combination of the above intended audiences, but the number of respondents who responded with multiple audiences never rose above 2 individuals per multiple category, thus we report here the main audience categories, which reflected 90.5%-98.5% of responses. Highest percentages are bolded. Highest percentages that indicated a response are bolded and italicized.

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Table 4 *Stated Venues for Multimodal Compositions*

Venue	Did not post	Blog	Wiki	Website	Twitter	Facebook/ Myspace	Instagram	Pinterest	Snapchat	YouTube	Instagram & YouTube	Instagram, Snapchat & YouTube	Website, Instagram, Snapchat & YouTube	Facebook/ MySpace & Instagram
Video														
Frequency	10	5	0	3	0	5	17	0	0	5	15	0	0	0
Percent	15.2	7.6	0	4.5	0	7.6	***25.8***	0	0	7.6	22.7	0	0	0
Cumu. %	15.2	22.7	0	27.3	0	34.8	60.6	0	0	68.2	90.9	0	0	0
Music														
Frequency	18	2	1	2	1	1	11	0	0	4	21	0	0	0
Percent	27.3	3.0	1.5	3.0	1.5	1.5	16.7	0	0	6.1	***31.8***	0	0	0
Cumu. %	27.3	30.3	31.8	34.8	36.4	37.9	54.5	0	0	60.6	92.4	0	0	0
FanFiction														
Frequency	26	2	0	4	1	1	5	0	0	3	24	0	0	0
Percent	**39.4**	3.0	0	6.1	1.5	1.5	7.6	0	0	4.5	***36.4***	0	0	0
Cumu. %	39.4	42.4	0	48.5	50.0	51.5	59.1	0	0	63.6	100.0	0	0	0
Digital Story														
Frequency	23	1	1	4	1	1	5	0	0	3	26	0	0	0
Percent	34.8	1.5	1.5	6.1	1.5	1.5	7.6	0	0	4.5	***39.4***	0	0	0
Cumu. %	34.8	36.4	37.9	43.9	45.5	47.0	54.5	0	0	59.1	98.5	0	0	0
Other														
Frequency	44	1	1	1	0	1	0	0	0	2	16	0	0	0

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Percent	**66.7**	1.5	1.5	1.5	0	1.5	0	0	0	3.0	***24.2***	0	0	0
Cumu. %	66.7	68.2	69.7	71.2	0	72.7	0	0	0	75.8	100.0	0	0	0
Photo														
Frequency	10	2	0	2		4	22	1	3	1	12	1	1	1
Percent	15.2	3.0	0	3.0		6.1	***33.3***	1.5	4.5	1.5	18.2	1.5	1.5	1.5
Cumu. %	15.2	18.2	0	21.2		27.3	60.6	62.1	66.7	68.2	86.4	87.9	89.4	90.9
Comics														
Frequency	24	1	1	4		1	4	1	1	2	25	1	0	0
Percent	36.4	1.5	1.5	6.1		1.5	6.1	1.5	1.5	3.0	***37.9***	1.5	0	0
Cumu.%	36.4	37.9	39.4	45.5		47.0	53.0	54.5	56.1	59.1	97.0	98.5	0	0
Anime/Manga														
Frequency	26	1		1		1	4	3	0	3	26	0	0	0
Percent	**39.4**	1.5		1.5		1.5	6.1	4.5	0	4.5	***39.4***	0	0	0
Cumu. %	39.4	40.9		42.4		43.9	50.0	54.5	0	59.1	98.5	0	0	0

Note: We also exhaustively asked about every combination of the above intended digital hosts, but the number of respondents who responded with three or more hosts never rose above 2 individuals per multiple category, hence, to save space we report here only the main digital hosting sites, which collected from 90.9%-100% of responses.

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Table 5 *Stated Overall Self Evaluation of Multimodal Compositions*

Multimodal Type	Value	Frequency	Percent	Valid Percent
Video				
Very displeased	1	4	6.06	6.06
Somewhat displeased	2	4	6.06	6.06
Neither pleased nor displeased	3	4	6.06	6.06
Somewhat pleased	4	31	46.97	46.97
Very pleased	5	23	34.85	34.85
Total	Mode=4	66	100.0	Mean = 3.98
Photo				
Very displeased	1	3	4.55	4.55
Somewhat displeased	2	5	7.58	7.58
Neither pleased nor displeased	3	5	7.58	7.58
Somewhat pleased	4	28	42.42	42.42
Very pleased	5	25	37.88	37.88
Total	Mode=4	66	100.0	Mean=4.02
Music				
Very displeased	1	4	6.06	6.06
Somewhat displeased	2	3	4.55	4.55
Neither pleased nor displeased	3	6	9.09	9.09
Somewhat pleased	4	34	51.52	51.52
Very pleased	5	19	28.79	28.79
Total	Mode=4	66	100.0	Mean=3.92
Comics				
Very displeased	1	5	7.58	7.58

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Somewhat displeased	2	5	7.58	7.58
Neither pleased nor displeased	3	4	6.06	6.06
Somewhat pleased	4	36	54.55	54.55
Very pleased	5	16	24.24	24.24
Total	Mode=4	66	100.0	Mean=3.80
FanFiction				
Very displeased	1	7	10.61	10.61
Somewhat displeased	2	6	9.09	9.09
Neither pleased nor displeased	3	34	51.52	51.52
Somewhat pleased	4	6	9.09	9.09
Very pleased	5	13	19.70	19.70
Total	Mode=3	66	100.0	Mean=3.18
Anime/Manga				
Very displeased	1	6	9.09	9.09
Somewhat displeased	2	3	4.55	4.55
Neither pleased nor displeased	3	6	9.09	9.09
Somewhat pleased	4	36	54.55	54.55
Very pleased	5	15	22.73	22.73
Total	Mode=4	66	100.0	Mean=3.77
Digital Story				
Very displeased	1	5	7.58	7.58
Somewhat displeased	2	2	3.03	3.03
Neither pleased nor displeased	3	4	6.06	6.06
Somewhat pleased	4	37	56.06	56.06

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Very pleased	5	18	27.27	27.27
Total	Mode=4	100.0	100.0	Mean=3.92

Note: No responses were provided for any other type of creation

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Table 6 *Stated Self Evaluation of Specific Aspects of Multimodal Composition*

Multimodal Type	Value	Frequency	Valid Percent	Cumu. Percent
Video				
None	0	**21**	31.82	31.82
Visual impact	1	11	16.67	48.48
Ideas/message	2	***13***	19.70	68.18
Structure/design	3	11	16.67	84.85
Audience comments	4	1	1.52	86.36
Technical skill	5	6	9.09	95.45
Visual impact, Structure/design, Audience comments, & Technical skill	7	1	1.52	96.97
Visual impact, Ideas/message, Structure/design, Audience comments & Technical skill	9	2	3.03	100.00
Total		66	100.0	
Photo				
None	0	**22**	33.33	33.33
Visual impact	1	***12***	18.18	51.52
Ideas/message	2	11	16.67	68.18

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Structure/design	3	8	12.12	80.30
Audience comments	4	3	4.55	84.85
Technical skill	5	5	7.58	92.42
All of the above	6	2	3.03	95.45
Visual impact, Structure/design, Audience comments, & Technical skill	7	1	1.52	96.97
Ideas/message & Structure/design	8	1	1.52	98.48
Visual impact, Structure/design & Audience comments	11	1	1.52	100.00
Total		66	100.0	
Music				
None	0	**26**	39.39	39.39
Visual impact	1	11	16.67	56.06
Ideas/message	2	***15***	22.73	78.79
Structure/design	3	6	9.09	87.88
Technical skill	5	6	9.09	96.97
Visual impact, Structure/design, Audience	7	1	1.52	98.48

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comments, & Technical skill				
Structure/design & audience comments	10	1	1.52	100.00
Total		66	100.0	
Comics				
None	0	**29**	43.94	43.94
Visual impact	1	8	12.12	56.06
Ideas/message	2	8	12.12	68.18
Structure/design	3	***10***	15.15	83.33
Audience comments	4	5	7.58	90.91
Technical skill	5	5	7.58	98.48
Visual impact, Structure/design & Audience comments	11	1	1.52	100.00
Total		66	100.0	
FanFiction				
None	0	**31**	46.97	46.97
Visual impact	1	6	9.09	56.06
Ideas/message	2	***10***	15.15	71.21
Structure/design	3	7	10.61	81.82
Audience comments	4	4	6.06	87.88

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Technical skill	5	7	10.61	98.48
Ideas/message & audience comments	12	1	1.52	100.00
Total		66	100.0	

Anime/Manga				
None	0	**34**	51.52	51.52
Visual impact	1	6	9.09	60.61
Ideas/message	2	***9***	13.64	74.24
Structure/design	3	7	10.61	84.85
Audience comments	4	4	6.06	90.91
Technical skill	5	5	7.58	98.48
Visual impact, structure/design & audience comments	11	1	1.52	100.00
Total		66	100.0	

Digital Story				
None	0	**29**	43.94	43.94
Visual impact	1	***9***	13.64	57.58
Ideas/message	2	8	12.12	69.70

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Structure/design	3	***9***	13.64	83.33
Audience comments	4	2	3.03	86.36
Technical skill	5	7	10.61	96.97
Visual impact, Ideas/message, Structure/design, Audience comments & Technical skill	9	1	1.52	98.48
Ideas/message, audience comments & technical skill	13	1	1.52	100.00
Total		66	100.0	
Other				
None	0	**49**	74.24	74.24
Visual impact	1	4	6.06	80.30
Ideas/message	2	2	3.03	83.33
Structure/design	3	***6***	9.09	92.42
Technical skill	5	5	7.58	100.00
Total		66	100.0	

Note. This table represents which categories of aspects (“visual impact,” “ideas/message,” etc.) and combination of aspects represent 100% of the choices made by the participants. However, if certain combinations of aspects offered for selection were chosen by no (0) participants, they were omitted from the table.

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Table 7 *Stated Self Evaluation of Specific Aspects of Multimodal Compositions by Others*

Multimodal Type	Value	Frequency	Valid Percent	Cumu. Percent
Video				
None	0	24	36.36	36.36
Visual impact	1	15	22.73	59.09
Ideas/message	2	14	21.21	80.30
Structure/design	3	4	6.06	86.36
Audience comments	4	2	3.03	89.39
Technical skill	5	4	6.06	95.45
Ideas/message & technical skill	6	1	1.52	96.97
Visual impact, structure/design and technical skill	7	1	1.52	98.48
Visual impact, ideas/message, structure/design, audience comments & technical skill	11	1	1.52	100.00
Total		66	100.0	
Photo				

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None	0	23	34.85	34.85
Visual impact	1	14	21.21	56.06
Ideas/message	2	11	16.67	72.73
Structure/design	3	9	13.64	86.36
Audience comments	4	4	6.06	92.42
Technical skill	5	3	4.55	96.97
Ideas/message & technical skill	6	1	1.52	98.48
Visual impact & structure and design	9	1	1.52	100.00
Total		66	100.0	
Music				
None	0	27	40.91	40.91
Visual impact	1	11	16.67	57.58
Ideas/message	2	14	21.21	78.79
Structure/design	3	4	6.06	84.85
Audience comments	4	5	7.58	92.42
Technical skill	5	4	6.06	98.48
Ideas/message & technical skill	8	1	1.52	100.00

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Visual impact, structure/design and technical skill		66	100.0	
Visual impact, ideas/message, structure/design, audience comments & technical skill				
Total		66	100.0	
Comics				
None	0	30	45.45	45.45
Visual impact	1	12	18.18	63.64
Ideas/message	2	10	15.15	78.79
Structure/design	3	7	10.61	89.39
Audience comments	4	1	1.52	90.91
Technical skill	5	5	7.58	98.48
Visual impact & structure/design	9	1	1.52	100.00
Total	66	100.0		
FanFiction				
None	0	32	48.48	48.48
Visual impact	1	8	12.12	60.61

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Ideas/message	2	14	21.21	81.82
Structure/design	3	5	7.58	89.39
Audience comments	4	3	4.55	93.94
Technical skill	5	4	6.06	100.00
Total	66	66	100.0	
Anime/Manga				
None	0	31	46.97	46.97
Visual impact	1	6	9.09	56.06
Ideas/message	2	13	19.70	75.76
Structure/design	3	8	12.12	87.88
Audience comments	4	2	3.03	90.91
Technical skill	5	4	6.06	96.97
Visual impact, & structure design	9	1	1.52	98.48
Visual impact, ideas/message, & structure/design	10	1	1.52	100.00
Total		66	100.0	
Digital Story				
None	0	28	42.42	42.42

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Visual impact	1	11	16.67	59.09
Ideas/message	2	14	21.21	80.30
Structure/design	3	3	4.55	84.85
Audience comments	4	1	1.52	86.36
Technical skill	5	7	10.61	96.97
Ideas/message & technical skill	6	1	1.52	98.48
Visual impact, ideas/message, structure/design, audience comments & technical skill	11	1	1.52	100.00
Total		66	100.0	
Other				
None	0	51	77.27	77.27
the visual impact	1	3	4.55	81.82
ideas/message	2	4	6.06	87.88
Structure/design	3	2	3.03	90.91
audience comments	4	3	4.55	95.45
technical skill	5	3	4.55	100.00
Total		66	100.00	

Note. This table represents which categories of aspects (“visual impact,” “ideas/message,” etc.) and combination of aspects represent 100% of the choices made by the participants. However, if certain combinations of aspects offered for selection were chosen by no (0) participants, they were omitted from the table.