Integrating Science and Writing in Multimedia Science Fictions: Investigating Student Interactions in Role-taking

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Abstract: We explore characteristics of group interactions in an afterschool program designed for middle school students to practice integrated STEM learning and digital literacies. In the program, students self-selected roles (e.g., writers, scientists, artists, and engineers) and worked in small groups to create multimedia science fictions. In order to understand the high integration level between science and writing in one focus group's final product, this study examines students' collaborative learning processes, the characteristics of their interactions, and their role-changing patterns. We found that the high integration level between science and writing may be explained by (a) the interactions between the writer and the scientist during discussion and multimodal composing, and (b) the catalyst role of the artist in the group discussion.

Keywords: interdisciplinary learning, role-taking, multimodality, science literacy, digital literacies, collaborative learning

Introduction

Scientific literacy lies in the intersection between the literacy skills of speaking, listening, reading, and writing, and scientific practices such as evaluating science ideas and communicating science ideas to others (Glynn & Muth, 1994; Norris & Phillips, 2003). While there is still no universal agreement on the definition of scientific literacy, the literature explains that writing is one critical tool for promoting scientific literacy. Along with the need for developing literacy skills on traditional print texts, many have called for an expanded view of literacy where the learner is supported as both a critical consumer and skillful producer of digital multimodal texts (NCTE/IRA, 2012). Consuming, integrating, and creating multimodal texts in digital environments involves new ways of thinking (Leu, Kinzer, Coiro, & Cammack, 2004; Mayer, 2008), including the task of making meaning between the interactions of multiple media and modes (e.g., visuals, sound, text, and movement) and moving beyond disciplinary constraints (Jewitt, 2009).

Deep learning requires an environment in which students take on identities they value and become heavily invested (Gee, 2005). This perspective on identity has been broadly studied in the scientific literacy field. For instance, Reveles, Cordova, and Kelly (2004) found that students could be supported in scientific literacy when they were provided with opportunities to enact the identity of scientist in reading, writing, speaking, and thinking about science. The same perspective on identity was applied to digital literacies education. For example, Vasudevan, Schultz, and Bateman (2010) analyzed the multimodal storytelling composing process of fifth graders and found that the students experienced meaningful learning by taking the role as writers and building literate identities on authorship and authority towards stories they wrote. However, there has been much less work devoted to support developing students' discipline-specific identities in interdisciplinary environments. In particular, there is a paucity of research examining the collaborative learning processes of adolescents embodying different real-life identities (e.g., writer, scientist, and designer) while working in small groups.

Integrating perspectives from science literacy and digital literacies, we developed an afterschool program aimed at engaging middle school students in collaboratively learning through making multimedia science fictions. The learning objectives for participants included developing digital literacies and STEM practices, forming creative and collaborative habits of mind, and learning about different STEM careers. In an earlier analysis, we developed a matrix to examine if the student-generated fictions integrated science and literacy well (Jiang, Shen, & Smith, 2015). In this study, we focused on student collaboration processes in order to understand the mechanisms that contributed to the varied integration levels of their final products. The following research question guided this study: What are the key characteristics of group interactions related to student roles that contribute to high integration between science and writing?

Methods

Program design

Our afterschool program was first piloted in spring 2015 in a public middle school in an urban Southeastern city in the United States. The research team included two university professors (one focused on STEM education and the other on literacy education), three doctoral students, and one undergraduate student. The two professors taught the program and the other team members assisted with the program development and research. Sixteen students (grade 6-8) participated in the study initially. Students worked in small groups of three to four to create digital multimodal science fictions. Each team member could self-select one of the following roles (with the requirement that each team has to have a writer and a scientist): (1) *Writers* were in charge of developing the science fiction narrative based on brainstorming sessions and discussions with group members; (2) *Scientists* were responsible for monitoring the inclusion and accuracy of science vocabulary, concepts, and background knowledge, as well as linking their story to "science entries" where they elaborated on science concepts; (3) *Artists* led the creation of visual and audio representations for all main characters and/or scenes in the story; (4) *Engineers* were accountable for designing buildings, vehicles, and settings for the story. Despite the differentiated roles, the team members were asked to collaborate with each other on their individual tasks. For instance, the artist may create a drawing of a character and the writer can write a paragraph to describe the character. The pilot study included nine weekly sessions (approximately 1 hour each). Table 1 outlines the session plans. Throughout the sessions, students were introduced to several technological tools, including Scratch, Bitstrips, and other tools for creating multimodal artifacts.

Table 1: Session plans

Date	Research Team	Student Activity	Expected outcome
Jan 15	-Introduce the project -Prepare some science fiction topics for discussion	-Understand the different roles for the project -Brainstorm/share fiction topics	-Students understand what participation in this project entails.
Jan 22 (Session two)	-Science topic/resources presentations -Tutorial on iKOS for writing science fictions -Scratch training session	-Create iKOS accounts -Learn Scratch for creating animations -Students form groups with guidance	-Student groups formed -Student roles decided -User accounts created -Students learn how to and Scratch
Jan 29 (Session three)	-Tutorial on story writing -Share ZEE's story (and elaborate on the roles)	-Small group works on their plot and further discuss each person's role and responsibility -Small group debrief	-Each group has an outline of a story
Feb 12	-Bitstrips Training session	-Small group discusses their story -Peer feedback session -Learn Bitstrioops for creating characters	-Each group learns what their peer group works on -Students learn to use Bitstrips
Feb 19	-Tutorial on how to include different science resources	-Small group works on their story/final product -Science knowledge check, search and sharing -Peer feedback session	-Each group learns what their peer group works on -Students understand the science involved in their fictions
Feb 26	-Milestone checks with each group	-Small group works on their story/final product -Group progress check	-Students meet the milestone check (Need to provide specific criteria/guidelines)
Mar 5 (Session seven)	-Role debrief	-Small group works on their story/final product -Role debrief (with groups of students of the same roles)	-Students refine understanding of their roles in relationship to their team work
Mar 12	NA	-Small group works on their story/final product	-Finish final products
Mar 19	-Evaluation	Final Presentation	-Present final products

All students used iKOS (ikos.miami.edu), an online knowledge building platform (Shen, Jiang, Chen, & Namdar, 2014), to create knowledge entries and multimodal science fiction stories. Figure 1 shows some screen shots from student artifacts.

(a) (b) (c)

Figure 1. Sample screen shots from student artifacts including uploaded student drawing related to their fiction (a), story in a lab log style (b), and graphics included in the story (c).

Data collection and analysis

Three of the four groups completed their final stories, entitled “Teleportation”, “ReptilianKing”, and “SuperSoldier”. Our earlier analysis (Jiang et al. 2016) examined the integration level of students’ multimodal science fictions. One of the integration aspect indicated how well science concepts were interwoven into the science fiction story line. For example, here was a sentence that was coded as high integration in story “ReptilianKing”: “The rebels released a gas Exavier had produced called Antidotum that could render Vennenum useless by having it combine with the Anidotum producing a harmless gas (a new substance) instead, in a chemical reaction”. The sentence demonstrated that an imaginary chemical reaction was incorporated in its key plot: Exavier, the main character, developed a material called Antidotum to protect the rebels from chemical weapon attack. It could form chemical reaction with Vennenum (a substance mined and used by the army of the Reptilian King as a chemical weapon) and release harmless gas. In contrast, story “SuperSoldier” had only included science vocabulary such as “clone” but did not weave these scientific ideas in their story narrative.

Among the three stories, the story “ReptilianKing” had the highest integration between science and story based on the aforementioned analysis. In this study we examined students’ group interactions and team dynamics that could have contributed to high integration in their final fictions. Our analysis drew on the multiple sources of data we collected: Screen captures together with audio records of students’ conversations; video records of students as they collaborated in small groups; knowledge entries including the science fiction chapters created in iKOS; semi-structured individual interviews with students to better understand their learning experience in the program.

Table 2: Coding categories that focus on examining whether students were enacting presumed roles

Code	Description	Example
Expected role = In-action role	Students act as roles that are the same as their self-selected roles (i.e., writer, scientist, artist, and engineer) during their speaking turns.	Student A: “what is the setting? How about in an alternate dimension?” (Student A, the expected “writer”, was discussing the story setting.)
Expected role ≠ In-action role	Students act as roles that are different from their self-selected roles during their speaking turns.	Student B: “Patrik (the name of a character), how about Logan?” (Student B, the expected “scientist”, was discussing the story characters.)
In-action role is general	Roles that students act as are general or obscure.	Student C: “what’s your idea?” (This statement from student C does not entail any role-specific information.)

We examined program sessions when the students had an opportunity to discuss and work on their project in small groups. We transcribed the discussion and removed off-task turns. We then coded the transcripts turn-by-turn using Atlas.ti 6.2 following the coding categories emerged from the analysis (Table 2). We specifically examined if the students were enacting their presumed roles in the project. Meaningful episodes were then selected to illustrate issues pertaining to the research question on investigating key characteristics of group interactions. Each episode consisted of a small set of consecutive turns among the group members. We focused mainly on the interaction between the scientist and the writer since the integration between science and writing was the focus of the study. In this paper, we only report findings from the group that demonstrated the highest integration level (group "ReptilianKing").

Findings

The analysis described in this section examined key characteristics of group interactions that related to student roles that contribute to high integration between science and writing in story "ReptilianKing". The storyline of the science fiction was centered on two characters who travel through a wormhole to rescue a partner only to get caught in a war between the Reptilian King and his rebels. The story had 2938 words in 160 sentences, among which 21 sentences contained science ideas. Students represented three roles in the group while creating "ReptilianKing". According to the first session survey, the scientist and the artist picked their first preference as their roles and the writer picked his second preference as his role.

The process: characteristics of group discussion

We selected three sessions to analyze student interactions because these sessions provided opportunities for them to work in small groups on their fiction writing and they also represented different phases into the project. In session two students formed small groups, picked preferred roles, and brainstormed fiction topics. In session three, students further brainstormed details in their story. In session seven, they worked toward finishing up their main story line.

Turn and time distribution across roles

We first looked at each member's contribution through turns they took. A turn is defined as the time period from the speaker starts talking to either a new speaker stops the speaker, or the speaker is cut-off, or the speaker finishes his or her turn in an overlapped transition, talking simultaneously with a new speaker who takes the subsequent turn (Silverman, 2006). There were 51, 105, and 59 turns in sessions 2, 3, and 7 respectively (Table 3).

Table 3: Distribution of participation in terms of number of turns and time in seconds

Session #	Writer	Scientist	Artist	Total
S2	16 (46.1)	16 (73.3)	19 (82.5)	51 (201.9)
S3	41 (351.0)	33 (130.3)	31 (100.1)	105 (581.4)
S7	22 (63.0)	14 (47.6)	23 (76.0)	59 (186.6)

We also tolled the time each speaker took (see Figure 2). In session 2, there was no notable difference in both the time and turn distributions across different roles. In session 3, the writer dominated the group discussion according to the time distribution illustrated in Figure 2. He tried to describe the whole story (e.g., plots and characters), and the scientist contributed science ideas and some plots most of which were included in the final story. The artist also wanted to add some plot ideas, but most of them were not included in the final story. In session 7, most of the time the artist explained her designs of characters and the writer gave some suggestions on the designs. However, the scientist rarely engaged in the discussion of designs. Instead, he pointed out that the writer's entry was less scientific and proposed to write another entry based on the writer's entry but in a more scientific way. That's why the scientist took the least talking time in session 7.

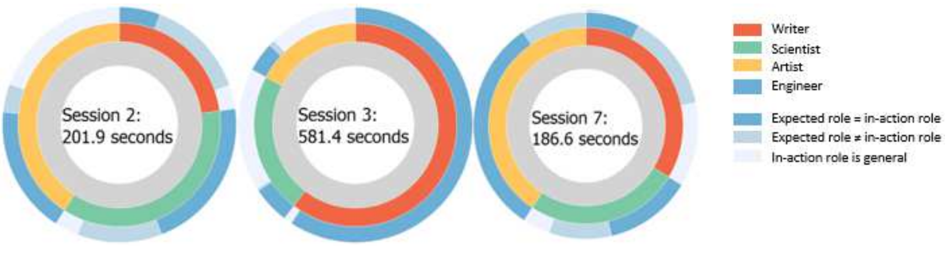

Figure 2. Time distribution according to role among the team members across sessions

Interaction patterns between the scientist and the writer

While examining and reflecting on the interactions between the scientist and the writer, we derived three interrelated themes that point to why this group produced a high science integration story. One thing to note is that this group had 3 members only; so only writer, scientist, and artistic were represented.

Theme 1: Adding science vocabulary to the story by the scientist. The scientist helped to add scientific vocabulary into the story while the writer described the plot. In the following excerpt from session 3, the writer explained that the main character developed a new technology that had the ability to make traveling possible to an alternate universe and then the scientist brought up the term "wormhole technology" without further scientific explanation.

Writer:	No, he is a human who is trying to use a new technology, a portal technology
Scientist:	Wormhole technology.
Writer:	Yeah, wormhole technology. To use it to transport, two porters, one in the northern part and one in the southern part…

In their final story, there were some sentences coded as low integration, such as the following one: "Rogue … activated the device and created a wormhole of gigantic proportions". These sentences contained science vocabularies, but they were not central to the story development.

Apparently, this kind of interaction between the scientist and the writer may not directly improve the integration level of the story. However, we want to stress that adding scientific vocabulary increases the potential for high integration since it can trigger the discussion about the science idea.

Theme 2: Building on each other's ideas to co-develop the story line. In this group, the writer and the scientist also frequently built on each other's ideas. For instance, the following excerpt occurred in session 3:

Writer:	It is kind of like an alternate universe, where, let's see, where men did not evolve, its species dominated. It took its place. Like the reptilian.
Scientist:	Yeah. The meteor did not hit the earth. And it did not die out.
Writer:	The dinosaurs
Scientist:	But that means that they have evolved eventually because it has been a long time.
Writer:	Yeah, it's intelligent. So our characters should be intelligent but looks like dinosaurs.

The writer thought that the setting was an alternate universe where human did not evolve and the scientist explained that the alternate universe should be a place that was different from the earth because it was hit by the meteor. Enlightened by the scientist's explanation, the writer set the species in the alternate universe to be species evolved from dinosaurs. This discussion was reflected in their final story with the following high integration sentence: "Yes, for you see the meteor you said was supposed to hit our planet as it did your Earth never quite hit us, therefore our species (species evolved from dinosaurs) didn't become extinct and we managed to survive and evolve.' said Muktav". These sentences not only contained science vocabularies with explanations but also elaborated on key elements in the story (in this case, the origins of key characters in the story).

Theme 3: Rewriting the writer's entry to elaborate on the science aspect. The scientist rewrote the writer's entry that contained a brief explanation on science ideas from the perspective of story plots and the writer hyperlinked the scientist's entry with their group final story. As shown in the following excerpt, the scientist proposed to rewrite the writer's entry in a more scientific way. The writer agreed and promised to hyperlink his entry with the scientist's entry. The rewriting behavior could also explain why the integration level is high because the scientist and the writer had a common understanding on the science idea in this context.

Scientist:	How about making an entry about the science? The entry you created is more about the story. I will make it more scientific.
Writer:	And when you finish everything, I will hyperlink to that one (I created which is less scientific) and it will be a hyperlink on a hyperlink.

The writer hyperlinked the scientist's entry "particle collider" with their final story. The following high-integration sentence in the final story reflected their discussion: "[Now nicknamed MOMENTUM, due to it causing molecules to bump into each other at an accelerated rate, causing a large dense mass to be created similar to particle collider (hyperlink to the scientist's entry) creating both black holes and wormholes] had reached its and further use would cause it heat up and shut down". In addition to providing an intensive description of the science idea, these sentences explained the functionality of the key device in the story: the "MOMENTUM".

Role-changing patterns

Figure 3 shows students' different role-changing patterns across sessions. Data points above (below) the x-axis represent that the student's in-action role is the same as (different from) his/her expected role. Data points on the x-axis represent that the student's in-action role is obscure or general.

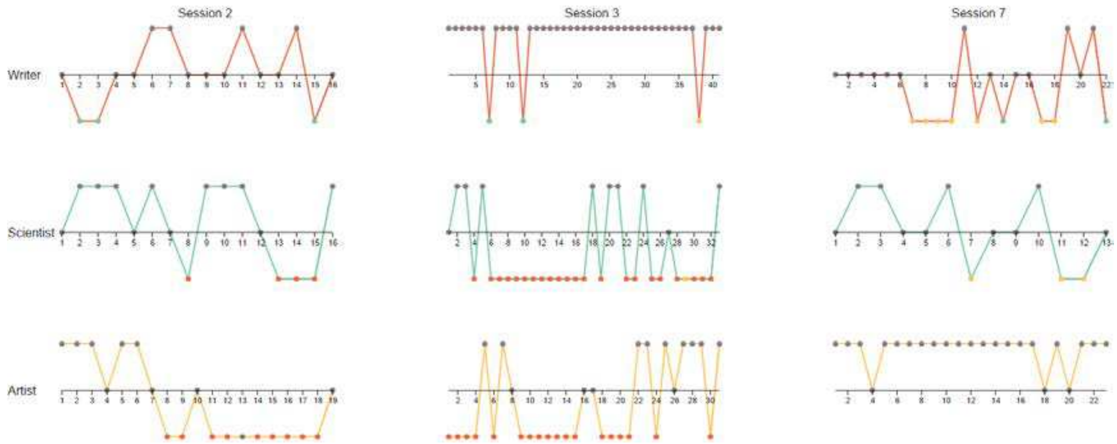

Figure 3. Role-changing pattern. Red represents writer; green represents scientist; yellow represents artist.

The writer. Overall, the writer played a leadership role in the group to coordinate with team members to push the story line for the group. He was also flexible at times to act as either a scientist or an artist. In session 2, the student mainly played the role of a coordinator. For instance, he invited other team members to express their ideas by stating sentences like "What type of Sci-Fi you want to write about?" He also started to take the role of scientist but gradually switched to be the writer. In session 3, he dominated the whole group discussion as a writer to discuss details of their story. For a couple of times he changed his role to be a scientist to respond to the scientist's suggestions. In session 7, he first worked as a coordinator and then he enacted as an artist to provide suggestions on the artist's designs. The writer's coordinating behavior might make the other group members feel that he was the dominator. He remarked in his post interview, "Although she [the artist] would probably say I am the leader, but I don't know, maybe I am".

The scientist. Overall, the scientist was faithful to his expected role to a great extent; he was also flexible to enact other roles. In session 2, the student started the group collaboration by taking his expected role to provide science ideas. He also enacted as a writer a few times later in the session when discussing with the team members about the story. In session 3, he constantly switched from scientist to writer to discuss the plot besides providing science concepts for the story. Recall on that session, a writing workshop was provided to all the students. In session 7, he worked more as a scientist and coordinator, but also contributed a few times as a designer. The scientist's role changing pattern was consistent with his interview response. He stated in the post interview, "I was supposed to be the engineer and scientist but turned out I did more work as a scientist or a writer sort of in between". Intuitively, the student's changing roles between scientist and writer helped contribute to the high integration of their final story.

The artist. Overall, the artist was very clear about her role in the group. At times, she enacted as a writer in order to join the conversation between the other two members. At the beginning of session 2, the student's in-action role was the same as her expected role, but later she changed her role into a writer to join the discussion between the writer and the scientist on brainstorming topics that they could write about. In session 3, she started as a writer to engage in the group discussion on describing plots and characters. Later, she disengaged herself from discussing the plots of the story since she was more interested in designs. Therefore, she changed back to be an artist to describe characters and search for pictures that match the descriptions online. In session 7, she showed her designs to the other two members and shared her insights about the designs. The observations also matched her interview responses: "My role is the artist and I animate everything. And I make sure the animations go smoothly and all of the visual effects. (Researcher: So did your role change?) Kind of, because I also did some of the other information and stuff, mostly I'm the artist".

Even though the artist's clear self-identification did not necessarily enhance an efficient interaction between the writer and the scientist, she served as a catalyst that initiated their interaction.

Artist:	It could be interesting if her age reversed. And her appearance will look differently.
Scientist:	Ok. The trick is due to wormholes, it works with time staff, and she has aged significantly than they should be. Significantly less, or
Writer:	Yeah, let's do it.
Scientist:	So Rogue reversed her age.
Writer:	She was originally 30 years old.

The artist brought up the idea of reversing age when discussing what would happen after one of the characters went through the wormhole. The scientist justified that it could be caused by the fact that the wormholes worked with time stuff, and the writer agreed on the idea and described that the character was originally 30 years old.

It is reasonable to argue that the high integration between science and writing for this group's final fiction was instantiated in their group interaction patterns. Specifically, the writer and the scientist enacted each other's roles frequently in order to carry out a fruitful conversation on both the story line and the science component. At times, the artist served as the catalyst for the interaction between the writer and the scientist.

Discussion

Our study examined how students' small group discussions and interactions were linked to their final products. We found that there were three different interaction themes between the writer and the scientist that possibly contributed to the high integration of their multimodal science fiction story: (1) The scientist adding scientific vocabulary into the story line; (2) team members building on each other's ideas to develop the story line; and (3) the scientist rewriting the writer's entry in a more scientific way. It is important to note that these themes were interrelated during their collaborations. The first theme is the base for the other two because the group would have science ideas to discuss and explore further only if someone brings in science vocabularies. The second and the third themes represented interactions from different angles: one from students' interaction on oral discussion and the other from students' interaction on composing artifacts.

We believe that these themes have practical implications in facilitating student collaboration beyond the specific context of our study. For instance, collaboration among learners can be facilitated at the surface level (e.g., bringing in different vocabularies) or at a deeper level (e.g., co-constructing artifacts). The key challenge is how to move the team members from the surface to the deeper level (e.g., using the surface level as a base for more fruitful collaboration). In addition, our themes also suggest that there are different objects students can co-construct (e.g., the conceptual storyline vs. the concrete knowledge entries in iKOS). A key research question is how to exploit the affordances and constraints of (and bridge accordingly) these different types of objects so that they mutually support each other.

Our research also examined the three students' role-changing patterns to explain the high integration level of the final story. Students self-selected their roles (accepted roles) as a writer, a scientist, or an artist at the beginning of the project, while their in-action roles were changing over time during their discussion. They tended to adopt and traverse their roles based on their interests, group dynamics, and the needs of the group. By comparing students' role-changing patterns across sessions, we see how the writer played a leadership role in addition to his expected role; the scientist was flexible in changing roles while fulfilling his expected role; and the artist was clear on her interest and utilized her advanced skills to be an artist. These observations pointed to the nuanced, dynamic, and complex processes in a collaboration environment. Besides team members understanding and enacting their specific roles in the collaboration process, our case hinted certain productive role-taking patterns: team members need to be flexible to flow between roles at times, (some) are willing to take on a leadership role, and (their participation) can elicit further interactions between other team members. Future empirical research should be devoted to understanding how we can design specific mechanisms to support these (or other) productive role-taking/changing patterns.

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