How Biographies of Women in Science, Technology, and Medicine Influence Fifth Graders’ Attitudes Toward Gender Roles

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Abstract
This research focuses on elementary pupils’ attitudes toward gender roles and the learning results from using two types of teaching materials, multimedia animation and a role-play transcript, based on the biographies of women in science, technology, and medicine. We selected two fifth-grade classes for the experiment, which was conducted during the students’ science period. The findings revealed that using the two teaching materials positively benefited elementary pupils’ attitudes toward gender roles, particularly in terms of games and toys.

Keywords
biographies of female scientists, multimedia animation teaching materials, role-play teaching materials, gender role attitudes of elementary pupils

Formation of Gender Stereotypes
Campbell Leaper (2013) pointed out that gender is a social category that shapes a person from birth. Gender roles and gender-related self-concepts tend to influence children’s interests in certain activities and divert their attention to issues associated with their gender. Gender peers and gender-based activities influence social behaviors of children. Given consistent exposure to gender-based play behaviors, girls and boys tend to lose opportunities to participate in other types of activities (Leaper, 2013). Play activities and games are important contexts for the socialization of genders because they provide opportunities for particular types of behaviors (Leaper & Friedman, 2007). Factors influencing choices in gender-based toy play include labels such as “for boys” and “for girls,” appearance, colors associated with masculine and feminine properties, and the corresponding concepts of gender-based toys conveyed to children through parents, family members, peers, and businesses (Weisgram et al., 2014).

Gender stereotypes are bound to social roles and reflect current occupational and societal trends (Eagly & Steffen, 1984; Eagly & Wood, 2016). In Wilbourn and Kee’s (2010) study on professional stereotypes among elementary school students, gender peers and gender-based activities influence social behaviors of children. Given consistent exposure to gender-based play behaviors, girls and boys tend to lose opportunities to participate in other types of activities (Leaper, 2013). Play activities and games are important contexts for the socialization of genders because they provide opportunities for particular types of behaviors (Leaper & Friedman, 2007). Factors influencing choices in gender-based toy play include labels such as “for boys” and “for girls,” appearance, colors associated with masculine and feminine properties, and the corresponding concepts of gender-based toys conveyed to children through parents, family members, peers, and businesses (Weisgram et al., 2014).

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children, researchers asked participants to create sentences with the names and occupations provided. The results revealed that children were less efficient in processing the counter-stereotype pairing of “male name-feminine occupation” (such as “Mark-nurse”) relative to the stereotype pairing of “male name-masculine occupation” (such as “Mark-dentist”). In addition, it took the children longer to pair male names with counter-stereotype occupations than it did for them to pair female names. Children’s preferences in the gender-occupation pairings in this study highlighted that occupation-related gender stereotypes remain strong in contemporary society. From the social role theory perspective, the formation and development of stereotypes change constantly. It is likely that men will assume more caregiving responsibilities in families and become employed in traditionally female-dominated occupations (Diekman & Eagly, 2000).

Introducing Female Images in Teaching Science

In 2008, the Taiwanese government made efforts to implement gender equity education and enact goals incorporating this subject matter into the curriculum. One goal of such effort is to assist students in understanding the diversity and differences in gender role development; however, despite this, the stereotypes in gender roles have remained in science education. During a round-table conference about gender issues in science textbooks held by the National Academy of Educational Research, participating scholars pointed out that the history of science in compulsory teaching materials depicted only male scientists and hardly mentioned female scientists, including the famous Marie Curie. At the end of the conference, participants agreed that increasing the representation of female role models in science is necessary to overturn gender role stereotypes in textbooks (Chuang et al., 2013). In the West, students assume that scientists are predominantly White males. Thus, several studies have pointed out that intervening in education and introducing stories of non-traditional science role models or involving female scientists in residence projects could effectively overturn students’ stereotypes of scientists (Bodzin & Gehringer, 2001; Flick, 1990; Huber & Burton, 1995; Mason et al., 1991; Rawson & McCool, 2014). Introducing female role models in science classes helps reduce female students’ self-imposed limitations in science and engineering subjects (Kahn & Githner, 2017; Mills et al., 2011; Stout et al., 2011). In addition, introducing stories about scientists from diverse cultural backgrounds humanizes them and makes science more accessible to students. This may lead to enhancing the link between students and scientific fields in the future (Sharkawy, 2012).

Multimedia Teaching and Role-Playing Teaching

With today’s rapid internet speed, multimedia videos are widely used as educational materials. Short videos for science education on online platforms are increasing so quickly that they are sometimes updated daily. Today, more than 60% of students are considered visual learners (Jukes et al., 2010) and referred to as the “digital generation” (Prensky, 2001). Weng and Yang (2017) found that 3D animations depicting stories of mathematicians and math concepts could improve the learning motivations of students toward math. Using multimedia animated cartoons to support teaching and learning in elementary science education can likewise significantly increase pupils’ knowledge and understanding of science concepts (Dalacosta et al., 2009). However, in a time when traditional didactic instruction can no longer satisfy students—although local multimedia teaching resources are still not very accessible—the Ministry of Education introduced the concept of including role-play as a way of teaching to Taiwanese teachers. In the chapter on Gender Equality Education of the Grades 1–9 Curriculum Guidelines enacted by the Ministry of Education of Taiwan in 2008, the ministry recommended role-play as a teaching method in many different subjects to help students respect different cultures and eliminate bias and stereotypes (K-12 Education Administration of Ministry of Education, 2008). Dorion (2009) believed that using role-play teaching methods in science classes could help students visualize and connect with abstract science concepts. Experimental teaching research by Muller et al. (2013) demonstrated that combining the teaching method of role-play and having scientists visit the class increased elementary students’ interest in science and their expectation of becoming scientists.

Purpose and Research Questions

This study focuses on the results of teaching in elementary school using biographical stories of local women in science, technology, and medicine. The research considers the lively and diverse learning environments characterizing elementary schools. In an attempt to reproduce similar effects of actual teaching conditions, this research used two non-traditional teaching materials to investigate students’ change in attitude toward gender roles after learning about the biographical stories of female scientists. The research questions are as follows:

Research Question 1: Will teaching using biographical stories of women in science, technology, and medicine, through multimedia and role-play, change fifth graders’ attitudes toward gender roles? 

Research Question 2: How will fifth-grade students’ attitudes toward gender roles change after learning about the biographical stories of women in science, technology, and medicine?

Method

Research Model

The experimental design of this research used two types of teaching materials common in non-traditional teaching
methods: multimedia animation and role-play transcripts; these were the independent variables. The dependent variable was the learning results of elementary school students' attitudes toward gender roles. Both groups of students were in their usual classes and with the same teacher to ensure a consistent teaching style. The experimental lessons happened over the course of 4 weeks during the “Science and Technology” class. The sample comprised students of two fifth-grade classes who were aged 10 to 11 years. There were 48 students in total, 24 from each class. One class was the “multimedia animation” group, which included 12 female and 12 male students. The other class was the “role-play” group, which included 11 female and 13 male students. The school and classes were in their normal setting; students were not informed that different teaching materials would be used in the classes to allow for efficient collection and analysis of data. This measure ensured they would experience natural learning conditions. In their original classroom with their regular teacher, teachers used the teaching materials on the students, incorporating the life stories of three women in science, technology, and medicine, respectively. The researchers took pre-test and post-test measurements in both groups using the “Gender Role Attitudes Scale.” The researchers measured four dimensions as key variables: personal traits, division of domestic labor, games and toys, and occupation of the “Gender Role Attitudes Scale.” The research field for this experiment was a science classroom in a public elementary school located in the downtown area of a medium-sized city of Taiwan. The school was equipped with a desktop computer and projector. The research variables were as follows:

Independent variables: multimedia animation and role-play;
Dependent variable: students’ attitude change toward gender roles;
Key variables: “personal traits,” “division of domestic labor,” “games and toys,” and “occupation” of four dimensions of the scale.

Stimuli and Teaching Materials

To build a positive perception of science and gender for students to ensure they are not limited by gender stereotypes in the field of science and technology, the researchers developed biographical role model teaching materials based on the publications of the Society of Taiwan Women in Science and Technology (TwiST), a renowned organization of women in science and technology in Taiwan. TwiST was established in 2011 as a network of female professionals in science and technology. One of its objectives is to encourage and motivate women to participate in science and technology. TwiST investigates the life stories of local women in science and technology, hoping to establish representations of female role models in science and technology in Taiwan. In addition to the monthly column on women in science and technology in their newsletter, TwiST also organizes a series of biographical videos and text publications. This research examines children’s picture book series and documentary videos of scientists from the TwiST publications, as well as female scientists’ profiles in the online newsletters. After three meetings with consulting experts and three teacher focus groups, we selected six stories on two scientists, two technologists, and two medical doctors. Finally, we selected one role model from each of the three fields of science, technology, and medicine and created the materials for the teaching experiment based on their biographies.

To compare the results of the two teaching materials used in the experiment, we controlled and based the multimedia animation and role-play on the same script. During the script-writing stage, we also interviewed the three role models in addition to using the TwiST publications as reference. We filmed and recorded these interviews for documentation purposes. We wrote the script after the data had been collected and used the script-writing process as the framework for developing the biographic story. Based on the outline, character setting, scene design, and dialogue writing, the script focused on the three female role models’ struggles and breakthroughs during their school lives and careers.

To adopt the script to elementary school classes, the length was limited to 5 min. After the script was established as the base of the teaching materials, it was later developed into a role-play script (Figure 1) and multimedia animation (Figure 2).

Analysis Tools

The analysis was conducted using SPSS 20 for Windows Statistics Data Editor.

Measuring Tools

This research used the Children’s Occupations, Activities, and Traits Scale (Liben & Bigler, 2002) as the measuring tool and modified the use of phrases in the scale to meet the habits of local elementary school students aged between 10 and 12 years. We developed the Children’s Occupations, Activities, and Traits Scale to measure children’s self-perception and attitudes toward gender roles. Its high reliability and strong validity have been confirmed (Bigler, 1997). The modified scale in this study was named the Gender Role Attitudes Scale. It was reviewed by three elementary school teachers and scholars trained in gender equality education and tested on 150 elementary school students, aged 10–12 years old, for reliability. Cronbach’s alpha was .95.

There are four dimensions to the Gender Role Attitudes Scale employed in this research. Each dimension includes five questions as follows:
Occupation: Who can be a doctor? Who can be a nurse? Who can be an engineer? Who can be a scientist? Who can be a beauty designer (e.g., make-up, hair, manicures, etc.)?

Division of domestic labor: Who can take care of children? Who can do the cooking? Who can support the family? Who can lift heavy things? Who can fix things (e.g., change the light bulb)?

Games and toys: Who likes mobile games? Who likes caster board? Who likes t-ball? Who likes ukulele? Who likes happy soccer?

Personal traits: Who can rely on others? Who can be rude? Who can be cute? Who can have long hair? Who can wear makeup?

Each question had three response options: “it’s for boys,” “it’s for girls,” and “it’s for both girls and boys.” Students were asked to choose one option after reading the questions. Both groups took the pre-test using the same scale sheets before the experimental teaching class. The post-test took place after the experimental teaching session was over.

Figure 1. Passages from the role-play transcript of the female technologist.
reduce the possibility of students giving the same answer to the post-test according to their memory of the pre-test, the order of the questions in the pre-test was slightly changed in the post-test. In the Children’s Occupations, Activities, and Traits Scale, which was referred to in preparing this questionnaire, each sub-questionnaire had a random order of question items (Liben & Bigler, 2002). This study only changed the order of questions within each dimension of the scale and did not go beyond the main purpose of the original scale, thus having a very slight impact on the study results.

Implementation Procedure

The multimedia group was taught using multimedia animation teaching materials, while the role-play group, using the role-play script. The session took 4 weeks, with 40 min of class each week. The first week was an overview of the three role models; one of the three women was introduced in each succeeding week. The class had three steps: first, the teacher introduced the role model of the week; second, each group proceeded with the animation or role-play, and the teacher occasionally intervened with supplemental information to deepen students’ knowledge about the role model; and third, the teacher guided the class discussions. Both groups of students remained in their original classes with the same teacher during the experimental classes. The students completed the pre-test and post-test, respectively, before and after the experimental class sessions, using the Gender Role Attitudes Scale.

Results

The results of the quantitative analysis of the Gender Role Attitudes Scale—aimed at measuring the changes in students’ attitudes toward gender roles after participating in the designed courses—are as follows: in total, data were collected from 48 participants, but 40 responses were valid. For each item, the responses “it’s for boys” and “it’s for girls” were counted as 1, and “it’s for both girls and boys” as 0. Higher scores indicated more stereotypical gender role attitudes, and lower scores indicated less stereotypical gender roles. Thus, if the total score of the post-test was lower than that of the pre-test, students’ attitudes toward gender roles were deemed to have changed in a positive way; otherwise, they were deemed to have been negatively impacted.

The Independent Samples t-Test

An independent samples t-test was conducted to examine the differences in attitudes between the multimedia animation group and role-play group before and after the course in which the biographies of female figures from the science, technology, and medicine fields were used (pre-test and post-test). The results indicated no apparent differences in attitudes between the two groups before and after participating in the course, suggesting that the attitudes of students in the two groups did not differ (Table 1).

The Paired Samples t-Test

Next, a paired samples t-test was performed to investigate the differences and changes in attitudes of the two groups before and after the course. Attitudes toward personal traits, division of domestic labor, games and toys, and occupation were examined. The differences between the pre-test and post-test of the multimedia animation group for the four dimensions were 0.2, −0.45, −1.2, and −0.35, respectively. The differences for the role-play group were −1.85, −0.55, 0.7, and −0.6, respectively. The overall differences between the two tests involving the multimedia animation group and role-play group were −1.8 and −2.3, respectively. These findings suggest that after participating in the designed course, students in both groups exhibited less stereotypical attitudes toward gender roles (Table 2); however, the level of significance of the differences required further examination.
Table 1. Results of the Independent Samples t-Test for Two Groups of Students.

| Independent variable | Group          | Pre-test (±SD) | Post-test (±SD) | t-value | p-value |
|----------------------|----------------|----------------|-----------------|---------|---------|
|                      | Multimedia animation | 33.65 (5.17)   | 36.1 (5.54)     | -1.13   | .26     |
|                      | Role-play         | 33.8 (5.54)    | 33.8 (4.81)     | -1.4    | .17     |

Table 2. Descriptive Results of the Paired Samples t-Test.

| Dimensions          | Group            | Pre-test | SD   | Post-test | SD  | SE | t-value | Significance |
|---------------------|------------------|----------|------|-----------|-----|----|--------|--------------|
| Personal traits     | Multimedia animation | 1.85     | 1.59 | 2.05      | 1.53| .34| -0.53  | .59          |
|                     | Role-play        | 2.95     | 1.60 | 1.10      | 1.68| .35| 4.56   | <.001        |
| Division of domestic labor | Multimedia animation | 1.70     | 1.45 | 1.25      | 1.58| .32| 1.69   | <.01         |
|                     | Role-play        | 1.90     | 1.58 | 1.35      | 1.75| .35| 1.27   | <.01         |
| Games and toys      | Multimedia animation | 1.95     | 1.73 | 0.75      | 1.51| .38| 2.81   | <.001        |
|                     | Role-play        | 1.15     | 1.34 | 1.85      | 1.59| .30| 1.41   | <.01         |
| Occupation          | Multimedia animation | 1.65     | 1.66 | 1.30      | 1.49| .37| 1.60   | <.01         |
|                     | Role-play        | 2.00     | 1.83 | 1.40      | 1.42| .41| 1.41   | <.01         |

Table 3. Results of the Paired Samples t-Test.

| Dimensions          | Group            | M    | SD  | SE  | t-value | Significance |
|---------------------|------------------|------|-----|-----|---------|--------------|
| Personal traits     | Multimedia animation | -0.20| 1.67| .37| -0.53   | .59          |
|                     | Role-play        | 1.85 | 1.81| .40| 4.56    | <.001        |
| Division of domestic labor | Multimedia animation | 0.45  | 1.19| .26| 1.69    | <.01         |
|                     | Role-play        | 0.55 | 1.93| .43| 1.27    | <.01         |
| Games and toys      | Multimedia animation | 1.20  | 1.90| .42| 2.81    | <.001        |
|                     | Role-play        | -0.70| 1.94| .43| 1.60    | <.01         |
| Occupation          | Multimedia animation | 0.35 | 1.18| .26| 1.32    | .20          |
|                     | Role-play        | 0.60 | 1.90| .42| 1.41    | .17          |

According to the paired samples t-test, the significance levels of the differences for the multimedia animation group were .59 for personal traits, .01 for division of domestic labor, .001 for games and toys, and .20 for occupation. The significance levels of the differences for the role-play group were .001 for personal traits, .21 for division of domestic labor, .01 for games and toys, and .17 for occupation. Thus, the differences in the dimensions of personal traits (p < .001) and games and toys (p < .01) were significant for the role-play group, while those in the dimensions of division of domestic labor (p < .01) and games and toys (p < .001) were significant for the multimedia animation group. Both groups demonstrated significant changes in the dimension of games and toys (Table 3).

The findings of the experiment demonstrate that incorporating biographical information of females in science, technology, and medicine fields into teaching materials for fifth-grade primary school students reduced stereotypical attitudes toward gender roles. Students from the role-play and multimedia animation groups responded positively to the designed course. After being taught “gender and science” concepts through teaching materials based on the biographies of women in science, technology, and medicine, students from both groups exhibited positive changes in attitude toward gender roles, and these changes were statistically significant. However, using different forms of biographical materials seemed to influence students’ attitudes in different ways. Changes in attitude toward the dimensions of personal traits and games and toys were more significant for students from the role-play group. Students from the multimedia animation group demonstrated significant changes in attitude toward the dimensions of division of domestic labor and games and toys. Thus, the two types of teaching materials influenced different dimensions of students’ attitudes toward gender roles.
Discussion

This study introduced biographical stories of women from the science, technology, and medicine fields (non-stereotyped personal traits) into the teaching materials. Two forms of materials were adopted (role-play scripts and multimedia animations). The results showed that students from both groups had significant changes in attitude toward gender roles for games and toys. After participating in the designed courses, students from both groups tended to consider majority of the toys as being “for both girls and boys.” Goldstein (1994) claimed that peer interaction and parents’ attitudes influence children’s choices of toys. The children’s toy choices also showed that their gender role attitudes were affected by social situations. This study found that utilizing the biographical stories of females in the science, technology, and medicine fields as teaching materials can influence primary school students’ attitudes toward gender roles when playing with games and toys.

However, students in both groups showed no apparent changes in their attitudes toward gender roles and occupations after participating in the designed courses. This finding suggests that incorporating female characters in the teaching materials was not an effective way of changing students’ stereotypes of gender roles and occupations. Dinella et al. (2014) found that among the factors influencing career interests, gender was the strongest predictor of career interest. Young women who are typical of their gender group report less interest in masculine careers and more interest in feminine careers. Rarely are there females in senior positions in industries that pay high salaries, such as science and technology. Furthermore, the visibility of female representatives in such occupations is relatively low. Although students were exposed to stories of counter-stereotype characters, their attitudes toward gender roles in occupations remained unchanged. Relevant here is the pre-stated social role theory, which is based on the similarities and differences in gender roles from a biological and socioeconomic perspective. The labor division by gender roles is supported by childhood socialization practices; hence, boys and girls tend to develop psychologies suited to their likely adult activities (Eagly & Wood, 2016). The results of this study showed that children’s aspirations concerning the relationship between occupations and gender might have been challenged by the biographical stories of female scientists, as students realized that females could also work in science and technology industries. They also understood that males could work in traditionally female-dominated industries; however, the changes in attitude were not statistically significant.

The stories presented in this study showed that some female characters faced the challenge of balancing work and family. This plot stimulated students’ reflections on the division of domestic labor. After participating in the course, the attitudes of students in the multimedia animation group seemed less stereotypical in terms of the division of domestic labor—a statistically significant finding. In modern society, watching cartoons is part of a child’s developmental process. The story contexts and behavioral patterns of cartoon characters are likely to become models for children’s behaviors. Here, social cognitive theory supports the finding that children tend to imitate behaviors on television and in cartoons (Bandura, 1986, 2009; Bandura et al., 1963). Cartoon animations such as Doraemon and The Simpsons, usually use the core family as the background for episodes associated with daily interactions between family members. Children who frequently watch animated cartoons are likely to acquire an understanding of role divisions among family members based on the storylines. In this study, students in the multimedia animation group demonstrated greater changes in their attitudes toward gender roles and the division of domestic labor after completing the designed course.

Furthermore, the attitudes toward gender and personal traits among students who participated in the course with role-play scripts for teaching materials changed significantly. Compared with the other group, students in the role-play group had fewer stereotypes in terms of gender-personal traits after participating in the course. Joyce et al. (2009) indicated that students engaged in role-playing as part of their curriculum may demonstrate an increased ability to recognize their own feelings and those of other people. Furthermore, their problem-solving skills are likely to improve. In this study, we asked students from the role-play group to think from the perspective of the characters they played and attempt to figure out their thoughts and feelings, make decisions, and take actions according to the development of the story. Students’ attitudes toward gender roles and personal traits were then reflected in their responses to questions such as “Who can rely on others?” “Who can be rude?” and “Who can be cute?” The fact that students’ attitudes toward gender and characters became less stereotypical following the course suggests that the application of role-play as a teaching method can effectively reduce prejudice and stereotypical images in relation to gender roles.

Conclusions and Recommendations

According to the results of this study, incorporating the biographical stories of female scientists in teaching materials can effectively help students establish a less stereotypical attitude toward gender roles. Specifically, the bias of students from both the multimedia animation and role-play groups decreased toward gender roles in terms of games and toys. In addition, the two types of teaching materials influenced children’s attitudes toward other dimensions of gender roles differently. The students who engaged in role-playing during learning activities were more likely to exhibit changes in their stereotypical attitudes toward personal traits, whereas those who enjoyed multimedia animations had less stereotypical attitudes toward the division of domestic labor. However, the introduction of biographical stories about
female scientists had no apparent influence on changing students’ attitudes toward gender roles and occupations. Thus, the recommendation is to combine multimedia animation and role-play scripts when using biographies of female scientists in class to provide students with a more comprehensive understanding of the gender concepts in the biographical stories.

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