JUNIOR HIGH FEMALE ROLE MODEL INTERVENTION IMPROVES SCIENCE PERSISTENCE AND ATTITUDES IN GIRLS OVER TIME

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ABSTRACT

This paper is based on the M.A. thesis entitled, "Long-Term Effects of a Junior High School Science Retention Program For Girls". The purpose of the thesis study was to identify the long-term effects of an intervention program aimed at improving science persistence and attitudes in girls over time. The measurement instrument was designed to gather subsequent attitudes toward women in science careers, secondary and post-secondary science course enrollment, consideration of a science career, and additional open-ended comments. Data were analysed using quantitative and qualitative methodologies. Results indicated that the intervention program was successful at improving subsequent attitudes, science course enrollment at the secondary and post-secondary levels, and the consideration of a science career. Results also indicated that respondents continue to have concerns about equal opportunity and the integration of a science career with family life. This study's findings and conclusions were discussed as they relate to researchers, intervention program organizers, women scientists, educators, students, and stakeholders from industry and government. Practical recommendations will be made to each of these groups on how we can work together to increase female participation in science-related careers.

INTRODUCTION

The problem addressed in the research study, "Long-Term Effects of Junior High School Retention Program for Girls", dealt with the under representation of females in science courses and careers. This under representation is a problem for society because the talent pool of scientists is considerably smaller without the participation of a number of potential female scientists. This under representation is also a problem for females because science careers could bring these potential female scientists higher status and an increase in earnings. This research study addressed the above problems by examining the effect that an intervention program (Operation Minerva Program) has had on subsequent science course enrollment and attitudes toward women in science careers. The Operation Minerva Program is a two-day intervention program that provides junior high female students with the opportunity to job shadow a female scientist and to participate in a science workshop (each is one day).

In an attempt to understand this problem further, the study addressed the following research questions:

- Question One: Do participants of the Operation Minerva Program possess very positive attitudes (average Likert score of 5 or more) toward women in science careers over time?
- Question Two: Have Operation Minerva participants pursued a high number of science courses (3 or more) at the secondary level?
- Question Three: Are a high number (70% or more) of Operation Minerva participants pursuing science at the post-secondary level?
- Question Four: Would a high number (70% or more) of Operation Minerva participants consider a future science career?
- Question Five: What themes emerge from the participants' additional comments?

LITERATURE REVIEW

The literature review outlined achievement and enrollment patterns in science courses at the elementary, secondary, and post-secondary levels, as well as participation patterns of women in science careers. This review indicated that female participation and achievement in science courses and careers is improving. The literature review also explored understandings about the attrition of female students from science courses and science careers by examining a number of biological, sociological, and educational influences. This review indicated that differences in performance seem to be explained by sociological, rather than biological, influences. Also, educational influences were found to be a major factor affecting the attrition of female students from science courses. A further review of literature provided an overview of female role models which in turn provided background information about the focal strategy used by the Operation Minerva program. The review indicated that following the exposure of a female scientist role model, both female and male students' attitudes toward women in science careers were improved. Finally, the review of literature focused upon attitudes influencing student achievement in order to provide a context for the measurement instrument used in this study. Literature revealed that positive attitudes result in higher achievement.

METHODS

The 1991 Operation Minerva Program provided job-shadowing and workshop opportunities to 114 junior high female students in Calgary, Alberta. Six years later, a mailout package containing the survey used in this study was sent to each of the participants using the 1991 addresses of their parents / guardians. As a consequence of change in address, 28 mailout packages were returned to sender. Of the 86 remaining mailout packages 34 were completed and returned to the researcher (response rate of 40%). The resulting research sample consisted of 34 females between the ages of 19 and 21.

The measurement instrument consisted of a questionnaire which was divided into three sections: Section One: Attitudinal Questions and Themes (from Smith & Erb's "Women in Science Scale", 1986); Section Two: Subsequent Science Course Enrollment and Consideration of a Science Career; and Section Three: Participants' Additional Comments.

Section One: Attitudinal Questions and Themes ("Women in Science Scale") consisted of 27 questions on a 6-point Likert scale from "strongly disagree" to "strongly agree". These 27 questions were organized into three emergent attitudinal themes: "opportunity", "compatibility", and "characteristics". The "opportunity" attitudinal theme was comprised of the concept that women and men ought to have equal opportunities to prepare for and pursue science careers. The "compatibility" attitudinal theme was comprised of the notion that women's roles as mother and wife are compatible with successful science career pursuits. The "characteristics" attitudinal theme was comprised of the notion that women possess characteristics which enable them to be successful in science careers. These variables are ordinal.

The purpose of the "Women in Science Scale" (WiSS) is to measure attitudes of adolescents toward women in science careers. Smith & Erb (1986) reported the WiSS to be a reliable instrument when cross-validated on the scores of the second half of their sample ($n = 612$). The coefficient alpha estimate of reliability equalled 0.92. The test-retest reliability of the WiSS was reported at $r = 0.82$. Smith & Erb (1986) established the validity of the WiSS by using two different procedures, known groups and correlates. The instrument distinguished between scores of early adolescents regardless of sex ($F = 322.24$, $p < 0.001$) and age ($F = 2.53$, $p = 0.02$) on the construct of interest. The predicted pattern of interest correlations was observed for both females and males when the WiSS was correlated with measures of five other constructs.

Section Two of the mailout questionnaire was developed by the researcher of this study. This section consisted of three tracking questions which identified subsequent science course enrolment and consideration of a science career. The first question in Section Two asked respondents to indicate their secondary science course enrollment activities subsequent to participation in the Operation Minerva Program. Respondents were asked to indicate the number of science courses taken in secondary school

using one of five potential responses: 1, 2, 3, 4, 5+. These variables are ordinal. For the purpose of inferential statistical analysis, responses to this question were further categorized. Two nominal categories were defined. Success was defined as secondary science courses ≥ 4 and non-success was defined as secondary science courses ≤ 3.

The second question in Section Two asked respondents to indicate their post-secondary science enrollment subsequent to participation in the Operation Minerva Program. Respondents were asked to indicate the statement which best described their science course enrollment prior to secondary school. Four potential responses were provided: enrolled in a university or college science degree / diploma / certification program; enrolled in a university or college non-science degree / diploma / certification program but have taken at least one post-secondary (after senior high school) science course; enrolled in a university or college non-science degree / diploma / certification program and have not taken a post-secondary (after senior high school) science course, or none of the above. With the exception of the "none of the above" response, these variables are ordinal. Two nominal categories were also defined for the responses from the second question in Section Two. Success ("science") was defined as enrolled in a university or college science degree / diploma / certification program or enrolled in a university or college non-science degree / diploma / certification program but have taken at least one post-secondary (after senior high school) science course. Non-success ("non-science") was defined as enrolled in a university or college non-science degree / diploma / certification program and have not taken a post-secondary (after senior high school) science course, or none of the above. The third question in Section Two asked respondents if they would consider a science-related career (yes / no).

The questionnaire concluded with Section Three. This section was optional and was completed by 22 of the 34 respondents (65% response rate). It was developed by the designer of this study in order to provide a space for respondents to add additional comments. These comments were then analyzed using Glaser & Strauss's "grounded theory". (Strauss & Corbin, 1990)

Quantitative research methods in the form of inferential and / or descriptive statistical analyses were employed on data from Sections One and Two of the questionnaire. Qualitative research methods were employed on data from Section Three of the questionnaire. An alpha level of 0.05 was employed for all statistical analysis.

RESULTS

Quantitative Research Methods

Quantitative research methods were used on data from Sections One and Two of the questionnaire in the following three analyses: Attitudinal Questions and Themes; Subsequent Science Course Enrollment and Consideration of a Science Career; and Comparison of Attitudinal Themes to Subsequent Science Course Enrollment / Consideration of a Science Career. Results were revealed as they related to each of the following research questions:

Research Question One:
Do participants of the Operation Minerva Program possess very positive attitudes (average Likert score of 5 or more) toward women in science careers over time?

Participants of the Operation Minerva Program maintain very positive attitudes toward women in science careers over time (6 years). These findings indicate that the Operation Minerva Program is a successful intervention program (using the criteria that it improves girls' subsequent attitudes toward women in science careers). As a consequence of the success of this program, future intervention programs should integrate contact with female scientist role models and associated workshops into their agenda.

Research Question Two:
Have Operation Minerva participants' pursued a high number of science courses (3 or more) at the secondary level?

According to the findings, 91% past Operation Minerva participants have pursued a high number of science courses (3 or more) at the secondary level. This finding implies that exposure to a female scientist role model and science workshop at the junior high level will encourage female students to pursue a high number of science courses at the secondary level.

Research Question Three:
Are a high number (70% or more) of Operation Minerva participants pursuing science at the post-secondary level?

According to the findings, a high number of past Operation Minerva participants (73%) are pursuing at least one science course at the post-secondary level. This finding indicates that exposure to a female scientist role model and science workshop at the junior high level encourages female students to pursue science courses at the post-secondary level.

Research Question Four:
Would a high number (70% or more) of Operation Minerva participants consider a future science career?

According to the findings, a high number (82%) of past Operation Minerva participants would consider a future science career. This finding indicates that exposure to a female scientist role model and science workshop at the junior high level encourages female students to consider a future science career.

Qualitative Research Methods

An analysis of qualitative data from Section Three of the questionnaire was conducted according to Glaser and Strauss's "Grounded Theory". (Strauss & Corbin, 1990) The open-ended comments section was completed by 22 of the 34 participants (response rate of 65%). Results were revealed as they relate to the following research question:

Research Question Five:
What themes emerge from the participants' additional comments?

Past participants of the Operation Minerva program commented on the benefits of the Operation Minerva program, influences on course and career choice, barriers, future recommendations to encourage females in science, and personal / general comments. The findings indicated that the Operation Minerva Program was a valuable experience and was successful at improving students' attitudes toward women in science careers. Findings also indicated that the classroom and workplace remain a "chilly climate" for females. Approaches to science teaching should include an experiential learning component in order to provide a more inclusive learning environment. These findings are consistent with literature recommending single sex classrooms in order to provide a more "girl friendly" environment. Findings also suggested that future efforts aimed at educating girls and society need to continue especially with respect to integrating personal and professional life priorities.

DISCUSSION

A summary and interpretation of the results were presented according to five analyses: Analysis One: Attitudinal Questions and Themes; Analysis Two: Subsequent Science Course Enrollment and Consideration of a Science Career; Analysis Three: Comparison of Attitudinal Themes and Subsequent Science Course Enrollment / Consideration of a Science Career; Analysis Four: Emergent Themes From Participants' Additional Comments; and Analysis Five: Comparison of Quantitative and Qualitative Results. These analyses answered the primary research questions of the study and extend the discussion about the problem being studied.

A descriptive analysis of attitudinal questions indicated that exposure to female scientists at the junior high level results in very positive attitudes by respondents toward women in science careers. A descriptive

analysis of attitudinal themes implied that respondents feel positive about their access to equal opportunity in science careers ("opportunity") and their capabilities to meet the needs of a science career ("characteristics"). However, this descriptive analysis suggested that respondents may be concerned with the integration of a science career and family life ("compatibility"). An inferential analysis of attitudinal themes suggested that the themes of "opportunity", "characteristics", and "compatibility" are related to one another. This finding suggested that each attitudinal theme is closely linked; therefore, positive attitudes toward each of the themes is dependent on the other two attitudinal themes. This finding further suggested that if participants' attitudes toward one of the attitudinal themes is slightly negative, it may negatively influence their attitudes toward the remaining two attitudinal themes.

The results from the descriptive analysis of subsequent science course enrollment and consideration of a science career suggested that following the Operation Minerva Program, respondents were more likely to enroll in secondary science courses, were more likely to enroll in post-secondary science courses, and were more likely to consider a science career. The results from the inferential analysis indicated that subsequent post-secondary science enrollment is not always affected by secondary science enrollment. Responses for participants' comments seemed to vary with respect to how important this additional emphasis is. The results of the inferential analysis also suggest that the consideration of a science career is not influenced by secondary science enrollment. However, the results indicated that if a respondent took at least one post-secondary science course, she is more likely to consider a science career. This finding suggested that subsequent post-secondary science course enrollment will encourage females to consider a science career. Junior high and first year university may be important critical intervention times with respect to the retention of women in science.

An inferential analysis was also employed to establish a correlation between attitudinal themes and subsequent science course enrollment / consideration of a science career. The results suggested that the attitudinal themes of "opportunity", "characteristics" and "compatibility" do not influence subsequent secondary or post-secondary science course enrollment. However, a respondent's attitude toward "opportunity" and "characteristics" does influence her decision to consider a science career. The attitudinal theme of "compatibility" does not influence a respondent's decision to consider a science career. This finding adds clarification to the earlier finding that each of the attitudinal themes is interrelated to the other attitudinal themes. Concern about the "compatibility" between a science career and family life is not necessarily a deterrent when considering a science career.

Results from participants' comments revealed that the Operation Minerva Program improved student attitudes toward women in science careers. Comments addressing encouraging influences on course and career choice stress the importance of self esteem and interest in academic and career choice; the importance of experiential learning as an important science learning strategy for females. Comments discouraging course and career choice focused on content difficulty experienced in secondary and university level chemistry courses. Barriers that remain a serious concern include struggles with issues of equity in the classroom and the workplace, and feelings of disconnection with male classmates in science courses. These findings are consistent with the conclusions of Gilligan (1982), and Belenky (1986) concerning the differences between females in their relation versus competitive approaches of interpreting the world around them. A small number of respondents suggested that they do not feel the above concerns are warranted. Future recommendations suggested that the key to encouraging females to pursue science careers is to continue educating girls and also attempting to educate the whole of society about this issue.

Implications of Using Two Methodologies

A comparison of quantitative and qualitative findings from the study, "Long-Term Effects of a Junior High School Science Retention Program For Girls", exemplifies the benefits of utilizing both research methodologies in future survey research. As a consequence of using both methodologies, this research study provided a broader and more in-depth understanding of the research problem. The use of both

methodologies strengthened the following findings: Operation Minerva improved subsequent attitudes toward women in science careers; subsequent science course enrollment at the secondary and post-secondary levels remained high; and a high number past participants would consider a science career. Also, as a consequence of a small number of supporting qualitative comments, the following quantitative findings may be supported: equal opportunities exist and women possess the characteristics needed for science careers.

If only quantitative research methods been used in this study, a number of suspect conclusions would have been made including: equal opportunities for males and females now exist; females believe they possess the characteristics needed to succeed in science careers; high school science course enrollment does not influence future science course and career choice; and the compatibility between family life and a science career is an area of concern. The above conclusions are suspect because the quantitative findings contradict the qualitative findings.

The use of both methodologies provided a number of new insights. Quantitative findings provided the following new insights: post-secondary science enrollment influences the consideration of a science career; attitudinal themes of "opportunity", "compatibility", and "characteristics" are dependent on each other; and the themes of "opportunity" and "characteristics" positively influence a girl's decision to consider a science career. Qualitative findings allowed for the following new insights: parental influence encourages science course and career choice; interest and ability influence science course and career choice; experiential learning positively influences science choice; secondary and post-secondary chemistry courses remain areas of difficulty; educational influences are not mentioned; and concern with the theme of "compatibility" was not mentioned.

RECOMMENDATIONS FOR FURTHER STUDY

Recommendations address two areas: the research process and the use for the substantive findings of the study. In order to develop a baseline for attitudes toward women in science careers, science course enrollment, and science career choice, this study depended on past research. The findings could be strengthened if they have been compared to a control group (similar geographical location, age, sex, but not exposed to a role model intervention program) in order to most accurately identify improvements in attitude, science course enrollment, and science career choice. This study should also be repeated on a larger scale for the purpose of adding validity and extracting a possible correlation between attitudes with secondary and post-secondary science enrollment. Also, in order to extricate more details on achievement and course choice, future research should collect science course marks and choice according to subject. Future research may also add depth to understanding by including a more comprehensive approach to qualitative research by interviewing some of the respondents in order to clarify and expand on additional comments. Future study should include both quantitative and qualitative research methods in order to provide a broader and more rich depiction of research problems.

Future research may also address some of the unexpected findings from this study. First, educators are not mentioned in respondents' comments. This silence could be due to a lack of effect or an unrecognized effect upon students concerning their attitude toward women in science courses and careers. Future research and intervention efforts should address the concern reported in this study on the ambiguity toward "compatibility" between a science career and family life. Further study should also address the current exclusionary approaches used to teach science (especially chemistry) at the secondary and post-secondary levels.

Future organizers of intervention programs should focus on counteracting the effect of sociological influences upon science course and career choice. Specifically, organizers should focus on the of breaking down stereotypical barriers such as traditional career stereotypes, stereotypical play, the perpetuation of gender stereotypes in school and work environments, and the integration of family life and a science career.

Women in science careers should make themselves available to intervention programs such as the Operation Minerva Program. Within these programs, female scientist role models should continue to

address concerns of associated with equal opportunity, characteristics required to pursue science careers, and the integration of a science career and family life. Female scientist role models will best serve girls who are interested in science by providing a real-life, honest example.

Educators should continue to encourage females to pursue science courses and careers, especially to encourage females to meet post-secondary science entrance requirements. Educators should also attempt to provide a more "girl-friendly" classroom environment through the use of more experiential and less competitive learning, as opposed to current approaches which concentrate on theoretical and competitive learning. Students should also be aware of the barriers they may encounter in science classrooms and work environments. They should use this awareness to help break down traditional stereotypes by seeking out modern-day female scientist role models.

Finally, other stakeholders from industry and government should continue to support intervention programs aimed at the retention of females in science courses and careers by continuing to provide funding to such programs, as well as encouraging employees to participate in role modeling opportunities.

Conclusion

The problem addressed in this research study was that of the under representation of females in science courses and careers. As a consequence of this under representation, the talent pool of scientists is considerably smaller without the participation of a number of potential female scientists. Also of concern is that many women with an interest in science do not receive the earnings and status that may have been provided in a science position. The intervention program that was evaluated in this research study attempted to encourage females to pursue science courses and careers in order to decrease attrition.

This study examined the effectiveness of the Operation Minerva intervention program by identifying subsequent improvement in female participant attitudes toward women in science careers, increased secondary and post-secondary science enrollment, and influence upon their consideration of a science career. This study indicated that the intervention program was successful at improving attitudes, science course enrollment, and consideration of a science career.

The significance of this study includes the potential use by various persons, as well as the contributions it may make to this field of research. Science educators may question why teachers were not mentioned in respondents' comments (either positively or negatively). These data confirm that female scientist role models are an effective strategy in combating science attrition by female students. Female scientists may also find this study interesting, particularly findings relating to respondents concern over the integration of a science career and family life; this is a topic for them to discuss further with their young mentors. This researcher concurs with the recommendation made by Donaldson and Dixon (1995) that the education of women must change to ensure that women and men "learn how to achieve a balance between family and career responsibilities." (p. 80) Results of this study may also motivate other members of society (such as representatives from industry and government) to be activistic and advise these stakeholders on how to be activistic with respect to encouraging young females to pursue science. Policy makers may also use the information from this study to develop policies to recruit more female science teachers and other non-traditional female role models, particularly at the junior high and first year university levels. This study will also be of significance to researchers investigating science retention of female students because it provides topics that should be studied further.

This study is unique in that it is a retrospective study. There is little previous research that gathers data on attitudes and course enrollment subsequent to participation in an intervention program. This study indicates that role model intervention programs for girls do improve attitudes toward women in science careers and encourage science course enrollment over time. The use of quantitative and qualitative research methods provided a broad, in-depth understanding of the research problem. As a result, a number of implications and future recommendations have been provided for researchers, intervention program organizers, educators, students, and representatives from science industry and government organizations.

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