

Retaining Girls in Science:  
Exploring the Effects of a Junior High Intervention  
Program across Educational Sectors

**2005-2007 Evaluation**



The Alberta Women's Science Network  
Athabasca University  
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## Project Overview

Driven by concerns over junior high girls losing interest in science, the Operation Minerva Program was established to provide girls with hands-on experience in various fields of science and engineering. This project, now in its 17th year in Calgary, has also expanded to urban and rural areas across Alberta (e.g. Red Deer, Medicine Hat, Fort McMurray, Athabasca, Grand Prairie and Pincher Creek). Approximately 90 girls and 90 female science mentors participate in the one-day Calgary Operation Minerva Program in May of each year.



Student participants job-shadow their mentor and participate in hand-on activities that bring out special aspects of the job. For example, a mentor in the oil and gas industry demonstrated how one can drill for oil by removing chocolate from a cake “round”. Students have also utilized three-dimensional software for generating geological models and examined mutations in fruit flies through the use of a specialized microscope.

This 3 year study entitled, Retaining Girls in Science: Exploring the Effects of a Junior High Intervention Program Across Educational Sectors, is funded by the National Sciences and Engineering Research Council of Canada (NSERC) with ethics approval from Athabasca University, the Calgary Board of Education, and the Calgary Catholic School District.

The purpose of this study is to explore the effects of the Operation Minerva Program across educational sectors (public, catholic, alternative) with respect to the intervention experience, course and career plans, and attitudes and factors influencing female science retention. The experiences of both students and science mentors are explored. Recommendations are provided for intervention program organizers, educators, women scientists, parents, and stakeholders from community, industry and government.

## **Literature Review**

### **Retaining Girls in Science**

Literature outlining gender differences in science achievement, enrollment, and employment reinforce the need to focus efforts on attracting and retaining females in science. At the elementary and junior high levels, girls perform as well as their male counterparts until age 13, when they begin to slip behind in science achievement (Connolly, Hatchette & McMaster, 1999). This gap increases each year until senior high, when females select few relevant electives, exhibit more negative attitudes and, by the end of high school, score considerably lower than boys in math and science (Oakes, 1990).

Enrollment patterns at the secondary, post-secondary and graduate levels reveal a similar trend. Compared to males, females enroll disproportionately more in senior high biology courses while avoiding other sciences, especially physics (Johnson, 1987). By university, women comprised only 22% of full-time students in engineering and applied sciences in 1997-98, up from 3% in 1972-73. Enrollment in mathematics and physical sciences rose from 19% in 1972-73 to 29% in 1997-98. By graduate school, the gender gap in science enrollment increases with women comprising only 23% of doctoral mathematics and physical science students, and only 16% of those in engineering and applied sciences (Statistics Canada, 2000, 87).

Recent statistics indicate that women remain the minority, representing 21% of engineering, mathematics and natural science professionals. Post-secondary enrollment statistics also indicate that females continue to be under-represented in engineering, mathematics and science (Statistics Canada, 2003, 10). Regardless of educational attainment across all disciplines, female university graduates employed full-time earned 73% of what men made in 1997 (Statistics Canada, 2000, 141).

### **Attrition: Biological, Sociological and Educational Influences**

Females decide not to pursue science courses and careers due to a combination of factors. Biological influences alone do not exclude girls from science; sociological and educational influences represent spheres that have a significant influence on attrition. Nevertheless, some scholars continue to use biology, and more specifically brain measurement (Moir & Jessel, 1991; Klekamp, Riedel, Harper, & Kretschmann, 1991), to justify girls' under-participation in science. Feminist scholars have critiqued these studies by highlighting the ways in which biological determinism has driven and ultimately distorted findings. As Kaplan and Rogers (1994) note, a desire to prove gender and race differences in brain functioning is an attempt to provide an apparent scientific rationale for the existing social order. Recent research exploring cognitive abilities suggests that gender is not a sufficient explanation for the under-participation of females in science. Following a review of twenty-three studies involving over 7,600 clinical interviews, McArthur and Wellner (1996) discover minimal gender differences in visual-spatial abilities. In their meta-analysis, Hyde and Linn (2006) considered more

than 5000 studies based on the testing of approximately 7 million people and found girls and boys to have similar cognitive abilities although significant gender differences were identified in the areas of physical aggression and activity level. These findings support the assertion that biology is not a sufficient explanation for female science attrition. Regardless, not all females, or males for that matter, are destined to be scientists. Of concern however, are those females who have science aptitude but leave science due to limited opportunity and a lack of necessary supports.

A number of scholars highlight the influence of factors other than biology on the attrition of females from science. Research on early childhood play reveals that boys are more competitive, confrontational and individualistic, while girls are more cooperative, accepting, sociable, and intimate (Grugeon, 1993). As children mature, more boys than girls report having participated in science-related activities. Although girls desired more involvement with science activities, they lacked previous experience (Kahle & Lakes, 1983). This lack of experience may be correlated to gender differences with respect to interest in science. Jones, Howe and Rua (2000) discovered significant gender differences in sixth grade students' attitudes and experiences related to science. While boys were most likely to have engaged in extracurricular experiences with a variety of tools such as electric toys, fuses, batteries and microscopes, girls reported experiences with bread-making, knitting, sewing and planting seeds. And while boys were more interested in atomic bombs, atoms, cars, computers, x-rays, and technology, girls reported interest in animal communication, rainbows, healthy eating, weather, and AIDS. Students' perceptions of science revealed significantly more females than males reported that science was difficult to understand, whereas more males reported that science was destructive and dangerous, as well as more 'suitable' for boys.

Differences in psychological development help to explain girls' focus on relationships as opposed to competition (Gilligan, 1982). Girls are particularly vulnerable during adolescence due to a strong relationship orientation, coupled with low autonomy and self confidence. This susceptibility greatly impacts a girl's construction of herself and significantly impacts her life choices. Science experiences that do not nurture these aspects of girls' psychological development can be enough to deter her from selecting science courses in high school and in turn, narrow her science course and career options in the future. Psychological differences and different access to science-related activities highlight the importance of providing girls with meaningful science experiences starting at an early age, especially at the junior high level.

A number of recent studies point to the role of parents in providing encouragement and access to out-of-school science experiences. In a study of naturally occurring family conversation, Crowley, Callanan, Tenenbaum and Allen (2001) found parents to be three times more likely to explain science to their pre-school boys than girls. Simpkins, Davis-Kean and Eccles (2005) discovered parents' behaviours to be powerful positive predictors of elementary school children's participation in computer, math, and science activities. In a study of parent-adolescent conversations about science Tenenbaum and Leaper (2003) discovered parents were more likely to believe that science was less interesting and more difficult for daughters than sons. They also found that parents'

beliefs significantly predicted children's interest and self-efficacy in science. When parents' teaching language was explored, fathers tended to use more cognitively demanding speech with sons than daughters. The above studies point to parental influence as an important factor in science retention. Parents should be aware of how their beliefs, behaviours and language can work to encourage or discourage their child's interest in science.

Teaching approach, classroom / school culture, student-teacher interaction, and peer influences each have significant educational influences on science attrition. In terms of teaching approach, gender inclusive strategies including an emphasis on relationships resonate with girls' interest in the connections to life, ownership of learning and a feeling of efficacy. In addition, facilitating learning through relational knowing does not deter male students from liking science (Hutchinson, 1996). Classroom culture also influences science attrition. An inquiry into graphic representations of scientists in classrooms revealed males made up 93% of images (Jones & Wheatly, 1989). In addition, science textbooks may contain subtle forms of sexism in the selection of language, images, and curricular content (Potter & Rosser, 1992). Research on student-teacher interaction in science classrooms revealed that females are at a disadvantage in terms of teacher time, (Haggerty, 1991) opportunities to carry out demonstrations, (Jones & Wheatly, 1989), and engagement in higher order questioning (Shakeshaft, 1986). Recent debates have focused on single-sex schooling in order to counter adolescent boys' dominant participation in the science classroom. However, findings from Dreves and Jovanovic (1998) clarify that girls with higher ability perceptions at the beginning of the school year were likely to remain confident throughout the year, actively engage in hands-on activities, and not perceive boys as the dominant participants in the classroom. While their findings suggest that the process by which girls come to view themselves as less able in science than boys is more complex than simply implicating dominance in the classroom, girls with lower confidence levels remain susceptible to classroom influences. Kessels (2003) further illuminates the impact of peer influence on science attitudes and interest. In a study of 8<sup>th</sup> and 9<sup>th</sup> graders, she discovered that girls perceived physics to be a masculine subject, and girls whose favourite subject was physics were perceived as more masculine than feminine. Both boys and girls held negative stereotypes (e.g. unattractive) of girls who liked or did well in science. Girls with good grades in physics considered themselves to be particularly unpopular with boys.

For girls with science aptitude, a number of interrelated influences can work to either encourage or discourage their continued participation in science. Future retention efforts should ensure that learning materials and hands-on science activities relate to girls' interests. Parents should be reminded that their beliefs, behaviours, and language have a significant impact on girls' science choices. Educators should be aware of gender bias in learning materials, classroom examples, and student engagement, and provide extra support and encouragement to promising female and male students. Parents and educators could also help to counter negative stereotypes associated with girls who do well in science by highlighting the exciting career options available to both girls and boys who decide to continue with science pursuits.

## Project Methodology

A total of 295 junior high girls participated in the Operation Minerva Program from 2005 to 2007, with 265 girls completing the survey (response rate 90%). Of the 265 respondents, 100 were from the public sector, 83 were from the catholic sector, and 82 were from the alternative sector (drawn from public, catholic, charter and independent schools). An estimated total of 90 mentors participated each year of the program with 77 completing the mentor survey over three years (response rate of 29%).

Table 1. Participation by Educational Sectors

Sector	2005	2006	2007	Total
Public	27	41	32	100
Catholic	29	31	23	83
Alternative	26	20	36	82
Mentors	29	21	27	77

Survey questions related to the Operation Minerva experience were imported from the Operation Minerva 2004 formative evaluation survey. One question was added to the mentor questionnaire: “what attracted you to becoming a mentor”. Questions related to plans for science studies and career choices were imported from MacDonald (2000). The exception is a question exploring senior high science course enrollment plans. This question was revised to gather more specific information on science course choice in the Alberta context.

Questions relating to attitudes influencing science retention were taken from Smith & Erb’s (1986) Women in Science Scale (WiSS), a tool used to measure attitudes of adolescents toward women in science careers. Five attitudinal questions from the twenty-seven item questionnaire were chosen for inclusion in the current research as a follow-up to a retrospective study of 1991 Operation Minerva program participants (MacDonald, 2000). While former Operation Minerva participants (six years following their participation in the program) were found to possess very positive attitudes toward women and science according to Likert scores, five of the twenty-seven questions revealed less positive attitudes. These five questions are included in both the student and mentor questionnaires in order to further explore these controversial statements. While these controversial questions do not relate specifically to science careers, they do focus mainly on statements related to family – career balance from the female perspective. Questions related to factors influencing science pursuits were generated from a literature review and included qualitative findings from MacDonald (2000, 2004). Quantitative data from questionnaires was analyzed according to descriptive statistics. Qualitative data from questionnaires was analyzed according to grounded theory (Strauss & Corbin, 1990) and presented according to the percentage of respondents indicating each theme.

## The Operation Minerva Experience

Participants indicated the most enjoyable and interesting features of their job shadowing experience were *hands on activities and exposure to applied examples (67%), exposure to female science role models and career options (29%), lectures, presentations and meetings (5%), and other (5%)*. ‘Other’ responses focused primarily on enjoying lunch with mentors.

Table 2. Most Enjoyable Features of the Operation Minerva Program

Most enjoyable features	Public	Catholic	Alternative	Total
hands on / applied experiences	77%	77%	45%	67%
exposure to female scientists & career options	32%	31%	23%	29%
lectures, meetings & presentations	3%	6%	4%	4%
other	7%	4%	2%	5%

The least enjoyable aspects of the job-shadowing experience included: *lectures, meetings & presentations (26%), amount / type of information (14%), not enough hand-on / applied science activities (7%), length of experience (4%), student groupings (2%), and other (9%)*. A number of respondents also commented that all aspects of the experience were enjoyable (14%). Comments related to amount / type of information suggested comprehension of some material was an issue. In addition, respondents recommended more time with mentors, and specifically more one-on-one time with mentors.

Table 2. Least Enjoyable Features of the Operation Minerva Program

Least enjoyable features	Public	Catholic	Alternative	Total
lectures, meetings, presentations	31%	17%	28%	26%
all enjoyable	17%	13%	11%	14%
amount / type of information	8%	27%	9%	14%
not enough hands on / applied experiences	7%	7%	6%	7%
length of OM experience	3%	5%	5%	4%
student grouping	2%	0%	5%	2%
other	10%	6%	11%	9%

Participants recommended the following improvements to the Operation Minerva Program: *more hands-on / applied science activities (23%), lengthen the experience (11%), student preferences for types of job shadowing experience (10%), smaller participant groups (10%), more time spent with mentors (7%), and ‘other’ (10%)* mainly related to coordination of transportation.

Table 3. Recommendations for Improvements to the Operation Minerva Program

Recommendations for OM Improvements	Public	Catholic	Alternative	Total
more hands on / applied experiences	18%	27%	24%	23%
lengthen / expand the experience	13%	8%	10%	11%
all positive / no recommendations	17%	10%	5%	11%
preferences for job shadowing experiences	7%	10%	13%	10%
smaller participant groupings	9%	7%	13%	10%
more time spent with mentors	6%	8%	6%	7%
other	6%	6%	20%	10%

Mentors were also presented with a series of open-ended questions related to their experience with the Operation Minerva Program. When asked “what attracted you to becoming a mentor” respondents indicated: *opportunity to encourage girls / promote science (68%), recruited through friend / workplace (18%), similar personal experience (17%), rewarding / opportunity to volunteer (9%), and opportunity to network with other mentors (3%)*. When asked if they enjoyed having the students for the time period given mentors commented on *the enjoyment of their time spent with student participants (38%), amount of time including ‘too much’ and ‘too little’ (14%), challenges / recommendations related to effectively engaging students (10%), effective student / mentor grouping (6%), and ‘other’ focused mainly on details of the experience (6%)*. Mentors were also asked what they gained from the Operation Minerva experience. Comments included *self reflection / rewarding experience (36%), interaction with students (32%), opportunity to inspire / potential impact (32%), and networking with other mentors (4%)*. When asked for recommendations on how to improve the Operation Minerva experience, mentors focused comments on *improved mentor / student preparation (19%), expanding / lengthening the program (10%), improved selection of students (ensure interest) (9%), match student occupational preferences (5%), and ‘other’ (5%)*. Commentary related to improved preparation focused on students as opposed to mentors and comments on the selection of students related to grade level, ensuring interest level, and targeting ‘at risk’ students.

### Science Course Enrollment and Career Plans

60% of Operation Minerva participants reported plans to pursue at least three senior high math and science courses. As outlined in Table 4, 71% Operation Minerva participants planned to enroll in pure math 30, 64% planned to enroll in biology 30, 60% planned to enroll in chemistry 30, and 48% planned to enroll in physics 30. This finding suggests that Operation Minerva is somewhat effective at encouraging girls to enroll in senior high school science courses. Level 30 science and math courses are a requirement for most post-secondary science programs and as such are critical to the pursuit of a career in science. The lower percentage of students planning to enroll in physics 30 is consistent with Johnson’s (1987) finding that girls enroll disproportionately more in senior high biology courses while avoiding other sciences, especially physics. (Johnson, 1987)

Mentors, intervention program organizers, parents and teachers should emphasize the importance of continued science and math course enrollment in senior high.

Table 4. Planned Senior High Courses by Sector (%)

Senior High Courses	Public	Catholic	Alternative	All Sector Total
pure math 30	70%	73%	68%	71%
chemistry 30	60%	58%	61%	60%
biology 30	67%	52%	73%	64%
physics 30	46%	43%	54%	48%

According to educational sector representation, the highest percentage of Operation Minerva participants planning to enroll in chemistry 30 (61%), biology 30 (73%), and physics 30 (54%) were from the alternative sector, and the highest number of participants planning to enroll in math 30 were from the catholic sector. It is also interesting to note that only 52% of catholic sector participants reported plans to pursue senior biology in comparison to 67% of public sector and 73% of alternative sector participants. This finding contradicts previous research that suggests girls are most likely to enroll in senior high biology courses. (Johnson, 1987)

As outlined in Table 5, 68% of Operation Minerva participants reported plans to pursue a post-secondary science degree or diploma, 23% of participants planned to pursue at least one post-secondary science course, 3% planned *not* to take a post-secondary science course, and 6% were unsure of post-secondary plans. A comparison of educational sectors reveals a high percentage of alternative (76%) and public (70%) sector participants planned to pursue a post-secondary science degree as opposed to only 59% of catholic sector participants. Considering 91% of participants plan to pursue a science degree / diploma or at least one post-secondary course the Operation Minerva Program is effective at encouraging girls to continue science course enrollment at the post-secondary level.

Table 5. Planned Post-Secondary Science Pursuits by Sector (%)

Post-Secondary Science Courses	Public	Catholic	Alternative	All Sector Total
post-secondary science degree	70%	59%	76%	68%
at least one post-secondary science courses	21%	33%	16%	23%
no post secondary science	3%	0%	5%	3%
unsure	5%	8%	4%	6%

It is interesting to note that while 91% of respondents reported plans to pursue science at the post-secondary level (either a degree or at least one course), only 60% of respondents reported plans to pursue at least three senior high science / math courses. This finding points to a disjoint between planned senior science and post-secondary science

enrollment. As stated above, mentors, intervention program organizers, parents and teachers should continue to stress the importance of senior science and math course enrollment as a prerequisite to most post-secondary science programs.

Table 6. Consideration of a Science Career by Sector (%)

Career Plans	Public	Catholic	Alternative	All Sector Total
science career	86%	90%	91%	89%
non science career	11%	10%	7%	9%

89% of Operation Minerva participants reported plans to pursue a science-related career. This finding suggests that the Operation Minerva Program is effective at encouraging girls to consider a career in science. Sector comparisons reveal minimal deviation. Themes from qualitative comments included *preferred occupations* (52%), *the influence of interest on science & career choices* (25%), *uncertainty over career choice* (12%), and *preference for non-science occupations* (7%).

### Attitudes Influencing Science Choices

As stated in the methodology, questions relating to attitudes influencing science retention were taken from Smith & Erb's (1986) Women in Science Scale (WiSS), a tool used to measure attitudes of adolescents toward women in science careers. Five attitudinal statements from the twenty-seven item scale were chosen for inclusion in the current research as a follow-up to a retrospective study of 1991 Operation Minerva Program participants. (MacDonald, 2000) A 6-point Likert scale was used for each statement (strongly disagree to strongly agree; 1 - 6). While these statements do not relate specifically to science careers, they do focus on attitudes related to family – career balance from the female perspective. In addition, while these statements were described by participants (students and mentors) as outdated and archaic, it is a useful exercise to explore controversial attitudes related to gender, career choice, and family-career balance.

Table 7 presents levels of agreement (including somewhat to strongly agree) for each statement. 13% of Operation Minerva participants across all sectors agreed that for a woman it is more important to be a successful wife and mother than it is to be successful in a career. 8% of participants agreed that getting married is the most important thing in a woman's life. 5% of participants agreed it was better for a woman to study home economics than chemistry, 4% agreed a woman's basic responsibility is raising children, and 3% agreed that careers are good for women as long as they are not the boss.

Comparisons across educational sectors reveal that public sector and catholic sector participants were more likely to agree with controversial attitudinal statements than alternative sector participants. Of particular interest, 19% of public sector and 12% of catholic sector participants agreed that being a wife and mother was more important than career success, and 10% of catholic sector and 8% of public sector participants agreed that marriage was the most important thing in a woman's life. These findings suggest

that career – family balance continues to be an area of concern (with family identified as the priority) for girls especially those from public and catholic schools.

Table 7. Agreement with Women in Science Attitudinal Statements (%)

Science Attitudes	Public	Catholic	Alternative	All Sector Total	Mentors
Careers are good for women as long as they are not the boss.	5%	2%	2%	3%	0%
A woman's basic responsibility is raising children.	6%	2%	4%	4%	8%
Getting married is the most important thing in a woman's life.	8%	10%	6%	8%	4%
For a woman it is more important to be a successful wife and mother than it is to be successful in a career.	19%	12%	6%	13%	25%
It is better for a woman to study home economics than chemistry.	5%	6%	2%	5%	1%

Qualitative themes from participant's additional comments related to attitudinal statements further illuminate concerns related to characteristics, opportunity, and compatibility. 24% of respondents provided commentary on *characteristics* indicating girls have the aptitude to succeed in science, 15% indicated *equal opportunities* exist, and 13% of provided commentary related to *compatibility* with the majority indicating women can achieve both career and family success.

Mentors strongly disagreed with three out of the five attitudinal statements. However, a surprising 25% of mentors agreed that being a good wife and mother was more important than career success and 8% of mentors agreed that a woman's basic responsibility is raising children. 4% agreed that getting married is the most important thing in a woman's life, 1% agreed that it is better for a woman to study home economics than chemistry, and 0% agreed that careers are good for women as long as they are not the boss. Additional comments from mentors focused on *compatibility* (integrating a science career with family life) (47%), *equal opportunities* exist (8%), and *characteristics* (women have the aptitude to succeed in science) (3%). The majority of mentors clarified that family and career success is possible with balance. In addition, the majority of mentors indicated the priority is motherhood over career especially when children are young. 25% of mentors and 12% of student respondents also reacted to controversial attitudinal statements describing them as outdated and archaic.

Overall, only a small percentage of participants and mentors expressed a level of agreement to controversial attitudinal statements. Regardless, it is interesting to note that family-career balance continues to be a contentious issue. Mentors, parents, and teachers should be encouraged to discuss science career compatibility concerns with girls;

highlighting success in both spheres is possible with balance. Stakeholders from industry should attempt to accommodate employees through flexible hours and job sharing as men and women strive to achieve a healthy work-family balance.

## Factors Influencing Science Retention

Potential factors influencing science pursuits were generated from a literature review and qualitative findings from MacDonald. (2000, 2004) Table 8 presents levels of agreement (including somewhat to strongly agree) for each factor across sectors and also includes mentor responses. Strongest reported influences reported by student respondents included: interest in science (90%), impact of female role models / mentors (85%), science ability (85%), and impact of classroom learning (77%). A high number of participants also reported parental influence (72%), impact of ‘out of school’ science experiences (66%), and impact of the peer network (63%). 38% of participants reported media and 16% of participants reported traditional stereotypes as factors influencing their decision to pursue (or not to pursue) science. Strongest influences reported by mentors included: interest (92%), ability (83%), parental influence (70%), out of school experiences (68%), classroom learning (62%), and role models / mentors (55%). Mentors also reported peer network (45%), media (26%), and traditional stereotypes (17%) influence science choices. It is interesting to note differences between student and mentor responses related to role models / mentor and peer network suggesting mentors underestimate the influence of these retention factors. Results support findings from MacDonald’s (2000, 2004) retrospective study of Operation Minerva participants that highlighted influences on science career choice including: parental influences, the positive impact of the Operation Minerva Program, the positive influence of interest and ability, and the positive influence of hands-on science learning.

Table 8. Factors Influencing Science Retention (%)

Retention Factors	Public	Catholic	Alternative	All Sector Total	Mentors
interest	89%	90%	91%	90%	92%
role models / mentors	82%	87%	87%	85%	55%
ability	84%	86%	87%	85%	83%
classroom learning	76%	73%	80%	77%	62%
parental influence	76%	61%	77%	72%	70%
out of school experiences	70%	64%	63%	66%	68%
peer network	57%	64%	70%	63%	45%
media	39%	40%	37%	38%	26%
traditional stereotypes	18%	18%	12%	16%	17%

Participant qualitative comments reinforce the impact of the following factors on science choices: *science interest and ability* (15%), *impact of the Operation Minerva Program* (5%), *social influences* (5%), and *hands on science learning* (5%). Mentor qualitative

comments focused on *recommendations for / the impact of intervention efforts (38%), hands on science learning (29%), societal influences (8%), and science interest and ability (5%)*.

Participants were asked to provide recommendations on how best to retain girls in science. Student comments focused on *recommendations for / impact of Operation Minerva (30%), the positive influence of science interest and ability (17%), the positive influence of hands on science learning (13%), and social influences (12%)*. Mentor comments focused on *recommendations for / impact of Operation Minerva (38%), the positive influence hands on science learning (29%), social influences (8%), and the positive influence of science interest and ability (5%)*. Recommendations for future intervention efforts focused on continued exposure to science career options through classroom speakers, role model and job shadowing opportunities, and videos.

Additional comments provided by participants focused on the *positive impact of the Operation Minerva Program (43%), recommendations for the Operation Minerva Program (9%), social influences (2%), and interest and ability (1%)*. Additional comments provided by mentors focused on *the positive impact of the Operation Minerva Program (41%), recommendations for Operation Minerva improvements (24%), social influences (20%), and the positive impact of hands-on science learning (14%)*.

## **Conclusion and Recommendations**

Findings from this three year study reveal minimal differences with respect to intervention experience, science course enrollment and career plans, science attitudes, and the impact of factors influencing attrition across educational sectors. Respondents across all sectors agreed that improvements to the intervention experience should focus on hands-on science activities, lengthening the experience, ensuring the provision of age-appropriate information, more one-on-one time with mentors, and matching occupational preferences. Mentors also recommended lengthening the experience and matching occupational preferences, and added improved student preparation and improved selection of students with interest in science as a prerequisite.

Planned senior science and math course enrollment revealed only 60% of respondents planned to enroll in at least three senior high science and math courses. This finding suggests that girls need additional encouragement to continue to enroll in science at the secondary level. In contrast, a high percentage (91%) of participants reported plans to pursue science at the post-secondary level (degree or at least one science course) and are considering a science career (89%). This finding highlights a disjoint between planned senior science and post-secondary enrollment and suggests that girls need to be reminded that senior math and science courses are prerequisites for post-secondary programs and science careers.

A few interesting differences were discovered across educational sectors. A comparatively low percentage of catholic sector participants reported plans to pursue senior high biology and a comparatively high percentage of alternative sector participants

planned to pursue senior high physics. In addition, a comparatively low number of catholic sector participants reported plans to pursue a post-secondary science degree. Educators, especially those from the catholic sector, should encourage girls with science aptitude to continue to enroll in senior science courses and consider post-secondary science degree programs.

A consideration of science attitudes influencing career choice revealed girls and mentors believe females have both the characteristics and equal opportunity to succeed in the scientific field. However, levels of agreement to attitudinal statements suggest concerns over family-career balance persist for both girls and mentors. While qualitative comments clarify respondents believe success in both spheres is possible with balance, future efforts should include continued discussion of this contentious issue. Mentors should be encouraged to discuss strategies used to achieve this balance in their everyday lives. A consideration of factors influencing science retention revealed interest and ability are powerful predictors of continued science pursuits. Role models, mentors, parents, peers and hands-on-science experiences were also reported to be influential science retention factors. Minimal differences across educational sectors appeared in relation to attitudes and factors influencing retention. The exception was a comparatively high percentage of public sector and low percentage of alternative sector respondents reporting concerns related to family-career balance.

Findings from this study are consistent with the literature review and suggest that the success of future retention efforts requires the understanding and contribution of a cross-section of stakeholders including educators, intervention program organizers, women scientists, and stakeholders from community, industry and government. Women scientists should make themselves available to intervention programs. Within these programs, role models should continue to address concerns related to family-career balance, engage girls in applied science experiences, and stress the importance of continued senior science course enrollment. Educators should continue to encourage girls in science through the use of hands-on, applied learning experiences, exposure to science career options, and the use of 'female friendly' examples and applications in order to connect to girls' interests. Parents should continue to encourage their daughters in science by engaging in 'out of school' applied science experiences, encouraging secondary and post-secondary science enrollment, and discussing science career options. Stakeholders from industry and government should continue to support science intervention programs through funding support, job shadowing opportunities, and encouraging employees to become mentors. While the Operation Minerva Program envisions a future full of possibilities for females in science, it is up parents, schools and science communities to work together to ensure that this vision becomes a reality.

Future Operation Minerva improvement efforts and other intervention programs should consider the following recommendations:

- mentor recruitment efforts should continue to tap into the networks of existing mentors, print and electronic advertising could also be improved
- consider lengthening and diversifying job shadowing experiences when possible
- mentor orientation should address:
  - the importance of engaging students with hands-on activities and limiting lectures, meetings and presentations
  - consider the comprehension level of students through a discussion of the junior high curriculum, mentors should be encouraged to link curriculum to the job-shadowing experience
  - ensuring one-on-one in addition to small group job shadowing experiences when possible
  - consider persistent concerns related to career – family balance, mentors to highlight success in both spheres is possible with balance
  - disjoint between planned senior high and post-secondary enrollment, mentors to stress the importance of senior high math and science enrollment as a prerequisite to post-secondary science courses and a variety of exciting career opportunities
- selection of participants should focus on students with identified aptitude in science in addition to an identified need for encouragement to sustain interest in the field
- provide mentors with a resource guide of possible hands on activities / demonstrations to accompany various professions
- consider an online registration process that also gathers student occupational and grouping preferences (occupational preferences should include a brief description), attempts should be made to match student preferences
- provide students with information on the mentor and / or company prior to the job-shadowing experience and ensure students are prepared to engage mentors with questions
- ensure mentors and students are informed of the SCiberMentor Program and other engaging science opportunities

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