PREFACE

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After lecturing to educators from Taiwan universities, Professor James Campbell and I invited Professor Wu-Tien Wu of National Taiwan Normal University for breakfast, a walk and a talk about our mutual interests in gifted youth. Out of our conservations came the idea for the research on the mathematical Olympiad participants described in this special issue.

For those interested in peak human performance, the Olympics offer intriguing subjects for study since they represent the best in each country and indeed the world by objective and competitive standards. It is surely an area in which people from different countries can learn much from one another. Intellectual Olympics offer something even more — a chance for countries to exhibit exemplary "human capital," the knowledge and skills of the elite. This might inspire other youth, and research might provide insights to coaches, educators, and parents so that larger numbers of youth can also benefit in a variety of fields.

Long experienced in cooperative international research, Professor Campbell designed the instruments for data collection and coordinated the analysis. He later took responsibility for linguistic and substantive editing of this issue. Professor Wu invited Asian colleagues from Beijing and Tokyo. Fortunately, Madame Zha and Professor Hirano accepted his invitation. I agreed to the minor role of advisor and supplier of a background review of previous research on gifted and accomplished youth. During the project, the team met in Toronto, Beijing, and New York.

For various reasons, the U.S.S.R. Russia representative could only join the project in its later stages (and could not participate in the data collection effort). We are honored, however, by his perspective in this issue since Russian educators and psychologists historically played leading roles in bringing about the mathematical Olympiad.

As it turned out, the countries represented here represent more than half the world's population and much of its land mass. The People's Republic of China alone screened more than two-million youths for participation in the mathematical Olympics.

As a cheerleader and advocate of this project, I applaud the huge efforts undertaken and brought to fruition by the team. They have used both quantitative and qualitative methods to inform us about the nature and nurture of young Olympic mathematicians. Their work should be of keen interest to educators and research workers not only in their own countries but throughout the world.

CHAPTER 1

DEVELOPMENT OF EXCEPTIONAL ACADEMIC TALENT: INTERNATIONAL RESEARCH STUDIES

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Abstract

This monograph deals with descriptions and evaluations of the Math Olympiad programs in five countries: United States, Taiwan, China, Japan, and Russia. This chapter provides the rationale underlying academic competitions that are designed to identify and nurture highly gifted individuals. The chapter also supplies the theoretical framework used in three parallel retrospective studies (United States, Taiwan, China), the results of which are summarized in separate chapters.

Introduction

Industrialized nations depend upon their scientific and technical personnel to maintain economic growth and vitality. These highly skilled personnel need the advanced training provided by colleges and universities. Each nation needs such personnel to adapt to the ever changing technical innovations that confront them. In the United States there are 6,211,344 scientists and engineers (S&E) in the labor force; 8% have doctorate degrees (National Science Foundation, 1996). An important question is how a country can get a steady supply of talented individuals to select these critical careers.

Every nation needs to keep close watch on potential recruits for the S&E workforce. This reservoir of talented individuals is found in elementary and secondary schools. Those deciding to pursue careers in science, engineering, and medicine are described as being in the S&E pipeline. For many talented students, the decision to enter the S&E pipeline occurs between grades 5 and 8 (Campbell, 1991; Terman, 1954). There is much leakage from this pipeline as students change their goals to pursue nontechnical careers. The end point of the pipeline is reached when students receive their bachelors, masters, and doctorate degrees in the technical areas and enter the S&E labor force.

In the U.S., the National Science Foundation (NSF) keeps tracking data on students who score in the top 10% as potential recruits for the S&E pipeline. The NSF sponsors an on-going national study of American students (Longitudinal Study of American Youth — LSAY) to determine the factors related to their career choices.

Academic Competitions

One way to identify exceptional talent in the technical areas is to sponsor academic competitions that are targeted at young people who are positioned to enter the S&E pipeline. The first organized academic competition for this purpose was started in China by the emperor Wu-Ti (Han dynasty 141–87 B.C.). He instituted examinations for civil service positions. Subsequent dynasties expanded and codified the extent of these examinations (Tiang dynasty 629–755; Sun dynasty 920–1127). These examinations helped to identify talented young people and funnel them into government service.

In the United States there are two kinds of precollege competitions that are designed to encourage high school students to select S&E careers:

1. preparation of research papers (write-ups of original research projects); and
2. testings.

In the first grouping there are three national contests of which the most prestigious is the Westinghouse Talent Search (started in 1941). Each year this contest accepts applications from approximately 1,500 high school seniors. These applications must include descriptions of original research projects in mathematics, biology, physics, chemistry, engineering, or the social sciences (psychology, anthropology, sociology). The research papers follow standard scientific methods and scholarly reporting procedures.

The 300 best papers are selected by the Science Service as semifinalists. From this pool 40 finalists are invited for a series of interviews. A final ranking is determined on the basis of the interviews and scholarships are awarded to the top finalists. Colleges and universities in the United States compete for the Westinghouse finalists and semifinalists. Their research skills are especially applicable at institutions that are committed to original research studies.

Over the 55-year history of this contest, 16,200 semifinalists and 2,160 finalists have been selected. The Science Service did a follow-up survey of the Westinghouse finalists and found that they won five Nobel prizes, two Field Medals, and eight MacArthur Fellowships. However, the finalists comprise less than 13% of the total Westinghouse sample. There has been no comprehensive follow-up study to ascertain the number of Westinghouse semifinalists and finalists in the United States S&E labor force.

Two other national research paper competitions are the Junior Science and Humanities Symposium (JSHS) and the International Science and Engineering Fair. The JSHS competitions are subdivided into 47 regionals, which are located in 48 states and Puerto Rico. The finalists from each regional attend a national meeting and compete for scholarships. Each year this competition involves more than 3,000 high school students (grades 9–12). The national conference has 240 finalists. Many of these finalists are also Westinghouse semifinalists and finalists.

The International Science and Engineering Fair is the largest research paper competition. In 1995 this competition reached 1,021,936 high school students (grades 9–12). This competition is organized with local school fairs, regional fairs, state fairs, and a national fair. Those selected for the national fair number 1,200 students. Again, many students enter other competitions and have the opportunity to win other contests.

The three research paper competitions attract only those high school students with the most highly developed research skills. Most of these students are proficient at using technical libraries and are able to read advanced technical journals and abstracts. This group has Scholastic

Aptitude Test (SAT) scores that frequently exceed 1300 (Campbell, 1991). Consequently, this elite group of students are annually ushered into the S&E pipeline.

The other kind of national competitions involves testing select groups of high school students. One of the largest testings is the National Merit Examination. Many highly talented high school students take these exams and earn scholarships with their high scores. Another national program, Study of Mathematically Precocious Youth (SMPY), tests 7th-grade students with the SAT-M (the Scholastic Aptitude Test Mathematics test). This program invites schools to test their top math students. The SMPY program provides year-round activities and summer programs to help develop this talent.

The other national testing programs are the Olympiad Competitions (mathematics, physics, chemistry). These competitions utilize multiple tests to isolate very small sets of finalists.

All these national competitions operate under the following rationale:

1. Children with exceptional talent should be identified during their formative years;
2. The competition itself will motivate the early development of the child's talent; and,
3. Once the talent is developed it can contribute to technical, medical, scientific, mathematical, and business innovations that can benefit the country (society as a whole).

Do these competitions serve a national purpose? Do they fulfill their goals? Do their participants actualize their potential? Since the larger contests do not exist in any of the Asian countries, the focus was limited to the Olympiad contests. The Math Olympiad program has been in operation both in the Orient and in the United States for almost a decade; therefore, Math Olympians would be available for examination in a series of retrospective studies.

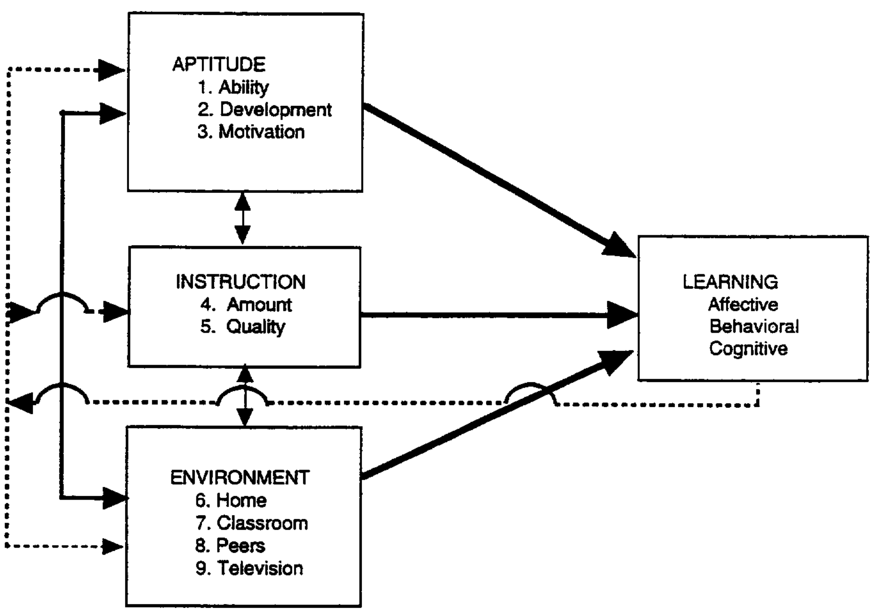

Figure 1.1. Walberg productivity model. Causal influences on student learning.

Theoretical Framework

An educational productivity model was proposed by Walberg (1984a, b, 1986). The model has the following components: Aptitude (ability, age, motivation), Instruction (quality of instruction, quantity of instruction), Environment (home, classroom, peers, television), and Learning.

The productivity model is illustrated in Figure 1.1. This causal model depicts direct influences of the nine factors on learning outcomes, together with a series of interconnecting arrows within these factors. These interconnections represent indirect effects on the learning variables.

The productivity model is an outgrowth of more than a decade of development. Walberg and Marjoribanks (1976) analyzed numerous research studies dealing with achievement within the frameworks of 12 analytic models. The most complex of these models contains five causal factors. Iverson and Walberg (1982) synthesized 18 of the most important studies involving

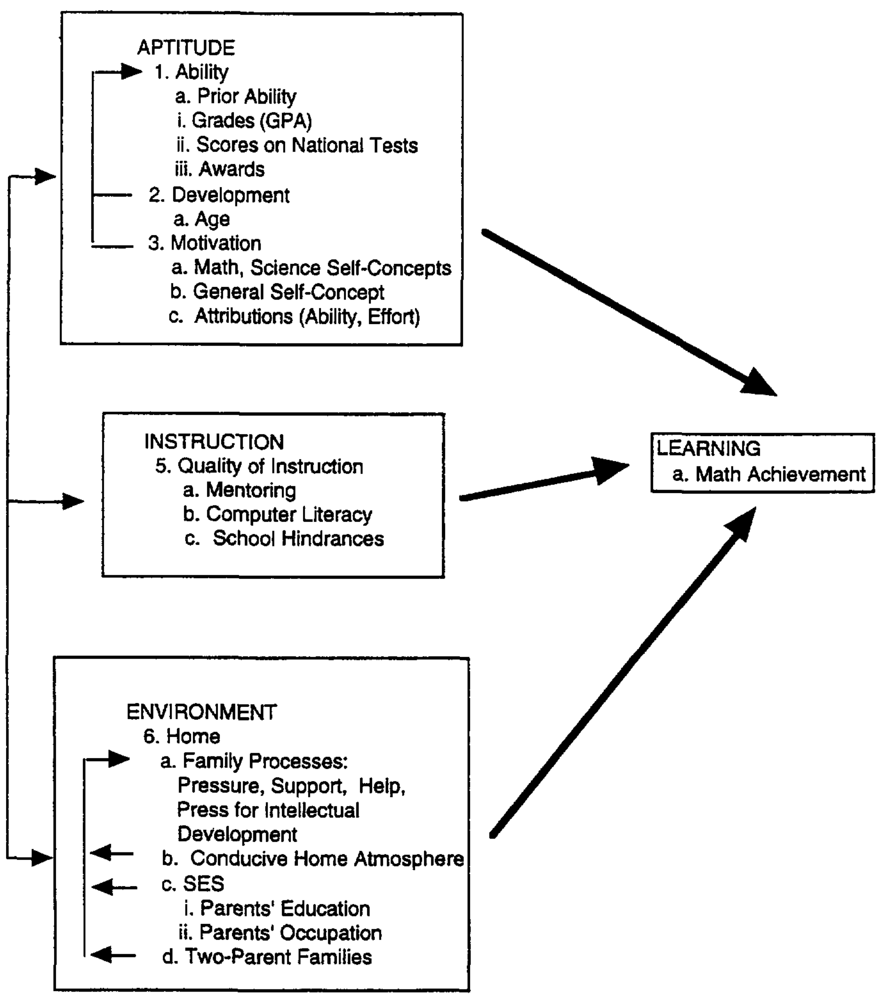

Figure 1.2. Interconnections analyzed within the Walberg productivity model.

home influences. They concluded that intellectual stimulation in the home has stronger influences on children's ability and achievement than socio-economic status indicators (p. 144). By 1984 Walberg had synthesized 2,575 empirical studies in the construction of an eight-factor model (1984a, p. 398). The media factor was added in 1986 in recognition of the growing importance of television in children's lives. The Walberg team (Wang, Haertel, & Walberg, 1993) has recently developed a more comprehensive framework that includes six theoretical constructs, 30 categories, and 228 variables. The productivity model, however, remains a core of the framework.

The Walberg productivity model was tested on 24 occasions (Reynolds & Walberg, 1990, 1992) and found to predict accurately achievement and attitude development. These tests used individual items or sets of variables within as many of the nine areas as possible. These global measures are used in regression or path analyses with math or science achievement as the dependent variables.

Campbell and his colleagues used the Walberg model in a number of international studies dealing with math achievement (Campbell, 1994; Campbell & Wu, 1994; Flouris, Calogiannakis-Hourdakis, Spiridakis, & Campbell, 1994; Pittyanuwat & Campbell, 1994). In these studies, path models were analyzed that contained specific factors from the Walberg model.

The Math Olympiad studies used the Walberg model in two ways:

1. As an organizing schema for the array of variables where data were collected;
2. In the path models that were tested.

In these studies different variables were subsumed within five of the global Walberg factors (see Figure 1.2).

Our adaptation of the Walberg Productivity Model expands the number of variables contained within the home to include family processes, a socio-economic factor, and a family structure variable (one/two parent families). In addition, the motivation factor has been expanded to include math and science self-concepts, general self-concept, and two attribution factors (effort, ability).

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CHAPTER 2

DEVELOPING CROSS-NATIONAL INSTRUMENTS: USING CROSS-NATIONAL METHODS AND PROCEDURES

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Abstract

The first section of this chapter deals with the research questions and the focus of the Olympiad studies. The next section concerns the development of the cross-cultural/cross-national instruments used in the international studies included in this monograph. One of these instruments (Inventory of Parental Influence) measures five family processes. Another instrument (Self-concept attribute attitude Scales — SaaS) isolates the Olympians' confidence in their math and science abilities, their general level of confidence, and their attributions for ability and effort. Another set of instruments pertained to the learning atmosphere in the home, and another dealt with school hindrances. The second section of the chapter describes the cross-national methods and procedures common to these studies.

Development of Cross-national Instruments

The Math Olympiad studies originated with collaborative contacts between American and Chinese scholars. After almost a century of research activity directed at gifted individuals, studies were needed to determine how well gifted students turned out. Of greater importance, there was a need to isolate the factors that either help develop talent or undermine it. The studies were organized around the two major research questions:

1. Do the Math Olympians make important contributions to mathematics, science, or to society in general? (Do they fulfill their high potential?)

Five specific questions were related to this question:

a. How many doctoral degrees were earned by the Olympians?
b. How many awards were won by the Olympians?
c. What pattern of advanced training have Olympians typically followed?
d. Do Olympians have a tendency to "burn out" early in their careers?
e. What factors undermine Olympians' career development?

2. What factors contribute to the development of the math talent of the Olympians?

Eleven specific questions were related to this question:

Home/Family
a. How important are socioeconomic factors?
b. What home factors contribute to their talent?
c. What home factors impede development?
d. Do the parents of Olympians use an optimal set of family processes?

School
a. How confident are the Olympians (in terms of math, science, and general self-concepts)?
b. How do the Olympians attribute effort and ability to their successes or failures?
c. Do the Olympians attain a high level of computer literacy?

Olympiad Program
a. What effect did participation in the Olympiad program have on these students?
b. Did it widen their horizons?
c. Did it open doors for them?
d. Were there negative side effects?

In order to get answers for these questions, accurate addresses for the Olympians from former years were needed to make contact with them. Since the Olympiad program of each country is national in scope, former participants were likely to be scattered over extensive distances. The Olympians were also expected to attend colleges and universities in different cities or even in different countries and afterward to relocate again. With all these changes, the only feasible approach to gaining information from them was to design a packet of instruments that could be mailed.

Information was gathered from Olympians and their parents for several reasons. First, the data assembled must be valid and reliable. One way to get such data was to collect the same information independently from the Olympians and from their parents. This approach permitted the verification of data by building in a replication process. This process also permitted the comparison of perceptions of different family members. Campbell and Wu (1996) analyzed family members' perception data in a study of 5th-grade Chinese students and their parents. When they compared the parent's perceptions with the children's perceptions, they found interesting differences among family members.

A second reason for collecting data from both sources was the expectation of missing data. The primary reason for isolating this academic contest, instead of other contests, was the exceptional ability of the participants and the small numbers of individuals who could be followed over the years. With such small samples of individuals available, obtaining data from as many former Olympians as possible was critical. Furthermore, some Olympians might not respond to the lengthy packet of instruments. In such a case, their parents might reply. Conversely, some Olympians might reply but their parents would not be able to respond. These parents may have changed residences or retired; some may have died. In either case, the overlapping of data would provide more complete information from the families of these talented individuals. Thus, these conservative methods would improve our ability to answer the research questions.

The design of the packet of instruments took more than a year to complete. The members of the international team were mailed preliminary packets and asked to evaluate them. The initial

questionnaires exceeded 24 pages and were judged to be far too long. The team recommended limiting the length of the main questionnaire to 12 pages.

The construction of the main questionnaire was aided by the instruments used in the Johns Hopkins University Study of Mathematically Precocious Youth (SMPY Follow-up Questionnaires). Campbell and Connolly (1987) used a modified version of the After High School Follow-up Questionnaire in a study of Westinghouse Talent Search winners. This experience proved invaluable in designing the Math Olympiad Instrument. Two other sets of questionnaires were used as sources of questions: the Longitudinal Study of American Youth (LSAY) and Campbell's international instruments. Dillman's (1978, 1991) Total Design Method (TDM) was followed in the layout of the questionnaire, the placement of questions, and the mailing schedule.

One segment of the SMPY Follow-up Questionnaire (After the High School Follow-up Questionnaire) was used to evaluate the Olympiad Program. This set of questions was believed to provide a fair assessment of the program. The other segments of the main questionnaire originated from the other two sources.

The contents of the main questionnaire were organized in the following areas:

Current information	
Family/School Influences (positive items)	School Influences (Hindrances) (negative items)
Evaluation of Olympiad Program	Starting College/Grad School (Programs in College/Mentoring)
Computer Literacy	College/University Degrees
Career Information	Academic Productivity (Articles, Books, Papers, Patents)
Background Information	
Type of school	Rank in Graduate Class
Extracurricular Activities	Awards
High School Grades	Standardized Test Scores
Generation	Religion
Ethnicity	Musical Interests & Ability
SES (including Resources and Books in the Home)	
Receptiveness of Society	Elitism Accusations

Dillman recommended several rounds of pilot testing of the questionnaire. The questionnaire was tried out with three groups (other researchers, teachers involved with the Olympiad program, and award winning high school students). These trial administrations of the questionnaires were exceptionally useful in evaluating the contents of the questionnaire and its design. Ambiguous questions were weeded out and others were included that were much more cogent. For example, the teachers suggested adding questions about high school grades and high school students recommended adding items dealing with the Olympians' musical interests and abilities.

After using these preliminary steps in designing the questionnaire, the Olympians' Questionnaire (OQ) was reduced to 14 pages of questions (including two blank pages for any in-depth discussions). The Parents' Questionnaire (PQ) contained ten pages of questions. Throughout this instrument a great deal of white space was included and the respondents were

asked to add qualitative information to clarify their responses. In addition to the main questionnaire, the Olympians' packet included the Self-confidence attitude attribute Scales (SaaS). The parents' packet contained the main questionnaire and the Inventory of Parental Influence (maternal and paternal versions). For these two inventories overlapping information was not available. The finalized packet of instruments were sent to the participants.

Several sets of items collected from the Olympians and their parents were factor analyzed using Principal Component analyses. These analyses uncovered 13 factors. The procedures recommended by Campbell (1994a) were followed in the construction of international scales. In order for items to be selected, they had to have factor loadings with sufficient magnitude in all international samples. Thus, the factor structures of the scales were replicated over the international samples.

Inventory of Parental Influence

The first section of the Inventory of Parental Influence (IPI) contains two scales designed to identify a family member's perceptions of two family processes: parental pressure and psychological support. These two processes are factor scales that have been developed from Likert statements. The respondents express their degree of agreement or disagreement with each statement: 1. strongly disagree, 2. disagree, 3. uncertain, 4. agree, 5. strongly agree.

Part II contains three factor scales made up of items relating to family practices: Parental help, press for intellectual development (PID), and monitoring/time management (MTM). Respondents were required to specify how often each practice occurred: 1. never, 2. rarely, 3. sometimes, 4. usually, 5. always.

One version of the IPI isolates children's perceptions of these five family processes. A second version of the IPI measures a father's perceptions (Paternal Version) and a third version deals with a mother's perceptions (Maternal Version). The parents' versions were used in the research studies reported included in this monograph.

The items making up the five family processes are included in Tables 2.1 and 2.2. The reader will have a better understanding of these family processes by analyzing some of the items in the parent's version of the IPI. To illustrate, for the pressure factor a high score is achieved if the parent agrees or strongly agrees with such statements as, "My child was afraid to come home with a poor grade." "I did not feel my child did his/her best in school." "I was only pleased when my child got 100% on a test." All of these statements suggest a demanding parent who exerts pressure to retain high levels of performance.

For the support factor, a high score indicates the parent agrees or strongly agrees with these statements: "I was satisfied if I knew my child did his/her best." "I had much patience with my child." "I am proud of my child." These statements suggest a psychologically supportive atmosphere at home. Parents who create such an atmosphere are believed to help their children to develop better academic self-concepts.

The helping factor measures how often the parent went over mistakes from a test, assisted with schoolwork, and helped the student to study before a test. The emphasis here is on the parents' giving the time needed to help the child complete his or her school work.

The press for intellectual development factor measures how often the parent encourages the child to read books, buy books as presents, and to watch educational TV. Families with high scores on this factor emphasize the importance of intellectual resources.

Table 2.1
Inventory of Parental Influence — Family Processes

	Pressure	Psychological support
Definition:	Children perceive parental influence with fear	Children perceive parent psychological support
	1. My parents are never satisfied with my grades	2. I feel happy when I get good grades because I know it pleases my parents
	3. I think I do well in school, but my parents feel I could do better	4. I do well in school mostly because of my parents' help
	6. My parents do not feel I'm doing my best in school	5. My parents feel it's important not to miss a day of school
	8. I'm afraid to go home with a failing mark	7. I'm glad my parents are concerned about my education
	10. I don't think I'm as smart as my parents think I am	9. My parents are satisfied if I do my best
	11. My parents don't believe me when I tell them I have no homework	12. My parents have much patience with me when it comes to my education
	13. My parents expect too much of me	15. My parents are enthusiastic about my education
	14. My parents pressure me too much with homework	17. My parents want me to go to a "good" college
	16. School would be more pleasant if my parents were not as strict	19. My parents take a big interest in my schoolwork
	18. When it comes to school, my parents expect the impossible	21. I get along very well with my parents
	20. My parents are "pushy" when it comes to my education	23. I feel that children my age need their parents' guidance when it comes to school
	22. My parents are pleased only if I get 100% on tests	24. My parents expect me to go to college
	25. I am basically lazy, and if it were not for my parents I would not be doing as well as I am in school	26. My parents are proud of me
	13 items alpha = 0.76	13 items alpha = 0.71

The monitoring/time management factor measures how often the parent sets rules on the kind of TV watched and requires the child to do his or her homework at the same time each night. Families with high scores in this area have distinct rules about homework, studying, and TV.

Conducive Home Atmosphere

Separate Principal Component analyses were performed for the Olympians' and their parents' responses to twelve statements dealing with family and school influences. The respondents were asked to rate the importance of these influences on the development of their math talent on a five-point scale: 0. none, 1. almost, 2. little, 3. some, 4. much, and 5. great.

Table 2.2
Inventory of Parental Influence — Family Processes

Definitions: Help	Press for Intellectual Development	Monitoring/Time Management
Children report frequency of parental help for homework and studying	Children report frequency that parents emphasize the value of books, reading and educational T.V.	Children report frequency that parents monitor their behavior regarding homework, studying and T.V.
27. When I bring home a test paper, my parents go over my mistakes with me	28. My parents like me to read right before I go to sleep	32. My parents keep track of the amount of time I give to homework
29. My parents visit my class whenever they are invited	31. My parents encourage me to go to the local library	36. My parents "bug" me with my schoolwork
30. My parents help me with my math homework	41. My parents want me to bring home test papers to see how well I did	38. My parents make me read books I don't really want to read
33. My parents help me with my schoolwork when I don't understand	47. My parents like me to read a lot	40. My parents set rules on the kinds of T.V. shows I can watch
34. My parents help me select books to read	48. My parents encourage me to read books	42. When I don't do well in school, my parents get me a tutor
35. My parents check my homework	49. My parents buy books for presents	44. I am expected to do my homework at the same time each night
37. My parents help me study before a test	50. When I am absent, my parents tell me to telephone a friend to get the homework	46. My parents insist I set aside a certain time for reading
39. My parents test me on my spelling words right before a test	52. My parents make me watch "educational T.V."	51. My parents determine how much T.V. I can watch
43. My parents help me with my school reports		
45. Before I leave for school my mother asks me if I have everything I need		
10 items alpha $r = 0.85$	8 items alpha $r = 0.83$	8 items alpha $r = 0.76$

Separate analyses isolated almost the same items for the Olympians and their parents (see Table 2.3). Families with high scores on this factor had abundant resources (books, magazines) and a stimulating intellectual atmosphere in their homes.

Confidence Scales

The Self-concept Scales are contained within the Self-concept attribute attitude Scales (SaaS) instrument. The scales use a five-point response format (strongly agree, agree, uncertain, disagree, strongly disagree) of negative and positive items. The items making up the self-concept scales are included in Table 2.4.

Table 2.3
Conducive Home Atmosphere

Importance of Family/School Influences

0	1	2	3	4	5
None	Almost	Little	Some	Much	Great

Olympians		Parents	
3.	Abundance of books in our home	3.	Abundance of books in our home
4.	Home atmosphere was very conducive to learning	4.	Home atmosphere was very conducive to learning
6.	Stimulating influence of a particular relative	6.	Stimulating influence of a particular relative
8.	There were specific books in our home that spurred my interest in math	7.	Stimulating peers
9.	Magazines that were accessible	8.	There were specific books in our home that spurred his/her interest in math
10.	Everyone in the family was an avid reader	9.	Magazines that were accessible
11.	My mother's recognition of math talent	10.	Everyone in the family was an avid reader
12.	My father's active encouragement	11.	Child's mother's recognition of math talent
		12.	Child's father's active encouragement

An operational definition of the math self-concept involves a continuum of confidence statements that relate to math. At one extreme an individual with a strong math self-concept strongly agrees with statements such as: "Math never scares me." "I enjoy doing math problems." The math-confident student strongly disagrees with these statements: "Math is dull." "Math makes me feel stupid." "I have always found math difficult."

At the other extreme an individual with a poor math self-concept is much more anxious about math classes or math tests. This individual strongly disagrees with the first set of positive statements listed above and strongly agrees with the negative statements. Chipman and Wilson (1985) expressed the view that confidence and math anxiety are opposite ends of a continuum; therefore, individuals with poor math self-concepts (low scores) have high levels of math anxiety (high scores). Westerback (1992) uncovered support for this view by finding a correlation of $r = -0.47$ between college students' math self-concepts and their math anxiety (Speilberg's State Math Anxiety Scale). Students with low scores in the Math Self-concept Scale were found to have high math anxiety scores. The science and general self-concept scales used the same procedures of including negative and positive items. Those individuals scoring high on the science self-concept scale are more confident in their science abilities; those scoring higher on the general self-concept scale are more psychologically confident.

Attributions

The two attribution scales are outgrowths of Weiner's (1980) attribution theory. Likert items (1. strongly disagree, 2. disagree, 3. uncertain, 4. agree, and 5. strongly agree) are used in these scales. Although this conceptualization contains four attributions (ability, effort, difficulty, luck),

Table 2.4
Self-concept attribute attitude Scales

Definitions: Math self-concept	Science self-concept	General self-concept
Olympians' confidence in their their math abilities	Olympians' confidence in their science abilities	Olympians' confidence in their general abilities
2. Sometimes it takes a long time to learn math	1. I have a lot of self-confidence in science	5. I take a positive attitude toward myself
3. I have always liked math	4. Science was hard for me	10. I often wish I were someone else
6. Math never scares me	8. Science is fun for me	15. On the whole I am satisfied with myself
9. I am poor in math	14. Sometimes it took me a long time to learn science	20. I feel I am a person of worth on a plane with others
12. I have a lot of self-confidence in math	18. Science is boring	25. Someone always seems to do things better than I
13. I do well in math only when the problems are easy	24. I have never liked science	30. I am able to do most things as well as most other people
19. I have always found math difficult	34. I feel uneasy about science	
22. Math makes me feel stupid		
26. I enjoy doing math problems		
29. Math is dull		
33. I hated doing math problems		
11 items	7 items	6 items

our Principal Components analyses with several samples produced two distinct scales, effort and ability (see Table 2.6) (Campbell, 1991, 1994b; Campbell & Mandel, 1990; Campbell & Wu, 1994, 1996; Flouris, Calagiannakis-Hourdakis, Spiridakis, & Campbell, 1994; Pitiyanuwat & Campbell, 1994). In each of these studies a consistent factor structure was found for the ability and effort factors.

Olympians agreeing with statements linking success and effort received high scores on the effort factor (see Table 2.5). The ability factor contains statements that attribute ability as the main reason for success. Several of the statements on the ability factor expressed the view that hard work could not overcome lower levels of ability.

School Hindrances

Both the Olympians and their parents were asked to rate the importance (0. none, 1. almost, 2. little, 3. some, 4. much, and 5. great) of twelve negative statements that have appeared in other studies. The Principal Component analyses uncovered seven items that indicate a very negative school atmosphere with insensitive and unprepared math teachers. Most Olympians and their parents had low scores on this factor (see Table 2.6), which indicates competent teachers and overall positive school atmospheres.

Table 2.5
Self-concept attribute attitude Scales

Definitions: Effort	Ability
Olympians' efforts attributions	Olympians' abilities attributions
36. I did poorly only when I did not work hard enough	38. There are some things you can't do no matter how hard you try
37. You can be successful in anything if you work hard enough at it	39. I worked harder if I liked the teacher
41. When I scored low on a test, it was because I didn't study hard enough	40. Being smart is more important than working hard
43. My achievement would have been better if I tried harder	42. You have to have the ability in order to succeed in most things
44. Self-discipline is the key to school success	52. When I did poorly in school it was because I did not have the needed ability
46. The smart kids tried the hardest	54. Why work in an area where your ability is low?
48. Poor study habits are the main cause of low grades	
51. I had to work hard to get good grades	
58. When I didn't understand something, it meant I didn't put in enough time	
59. I could have done better in math if I had worked harder	
60. Hard work is the key to get good grades	
63. I let people down when I don't work hard enough	
12 items	6 items

Using Cross-national Methods and Procedures

To facilitate the comparisons among the studies presented in this monograph, the demographic variables used to describe families were kept as similar as possible. The demographic variables (see Table 2.7) include family structure (one- and two-parent families), educational level attained by mother and father, immigration status of each member of the family (country of birth), occupational status of father and mother, income of parents (for the Americans), and some measure of the students' prior academic ability. Several of these variables were used as measures of socio-economic status (SES).

To use these variables in the path analyses they needed to be converted into interval scales. Seigel and Duncan developed interval status scales from the parents' occupations (see Miller, 1991), but both scales are limited to males. With the influx of many women into the workforce, such scales are no longer as useful. Instead, the Nam-Powers Scale was selected (see Nam & Powers, 1983; Nam & Terrie, 1982). This scale was derived from U.S. Census data. It contains three SES measures: occupational status scales (male and female), a parent's education scale, and a parent's income scale. Each of the scales ranges from 0 to 99. The most comprehensive

Table 2.6
School Hindrances

Importance of School Influences/Hindrances

0	1	2	3	4	5
None	Almost	Little	Some	Much	Great

Olympians		Parents	
1.	Some very poor math teachers	1.	Some very poor math teachers
2.	I knew more than many of the teachers — especially math	2.	He/she knew more than many of the teachers — especially math
3.	Some teachers were not respectful of my talent	3.	Some teachers were not respectful of his/her talent
4.	Insensitivity of some of the teachers	4.	Insensitivity of some of the teachers
7.	Math classes "Premature tombs"	7.	Math classes "Premature tombs"
8.	Utter boredom of some math classes	8.	Utter boredom of some math classes
11.	Prision-like atmosphere — especially in junior or senior high school	11.	Prision-like atmosphere—especially in junior or senior high school

scales are the occupational status scales that list status scores for professionals, managers and administrators, sales workers, clerical workers, craftsmen, transport equipment operatives, laborers, farm workers, and service workers. Each job has an assigned score for men and full-time working women. Parents' occupations were secured from self-report data supplied by the parents or by the Olympians. These data were then converted into status scores.

The Nam-Powers education scale has a conversion table for the parents' level of education. This conversion scheme was used to keep the education of the parents on the same metric as the occupational status scales. This scale is listed in Table 2.7. There is also an income conversion scale that was used for the American study.

The psychometric qualities of the Nam-Powers scale were analyzed by Miller (1983). He found a correlation of $r = 0.97$ between this scale and the Duncan index. High levels of reliability ($r = 0.96$) were also found for men's occupations and lesser correlations for women's occupations ($r = 0.85$).

The Nam-Powers scale was used in other international studies (see Campbell, 1994). For example, in the United States the Nam-Powers score for a common laborer was 07; for a skilled worker, 52; and for a physician, 99. These status scores represent relative status positions. In the China samples, these scores might be higher or lower than the Americans. Thus, the Nam-Powers conversions are only useful as relative/approximate estimations of social status. It is not possible to compare the occupational status of the two samples in any absolute sense.

In the three research studies, an SES composite variable was created by combining the mother's and father's occupational status and educational levels of attainment into a single factor. In all cases these SES variables underwent Principal Component analyses, and the composite SES variable was then used as one of the predictors in the path analyses.

Table 2.7
Socio-economic Status and Prior Variables

Variable	Label	Definition
Socio-economic	SES	Mother's & father's occupational status (Nam & Powers, 1983)
Mother's occupation Father's occupation	MOCC FOCC	Occupational status derived from census statistics (Nam & Powers, 1983): Values range from 00 to 100 Professional — range 70–100 Blue collar — range 05–65 Farm workers — range 01–43
Mother's education Father's education	Mo.Ed. Fa.Ed.	1 = Less than high school 2 = High school graduate 3 = Some college 4 = College graduate 5 = M.D./Ph.D./Lawyer Nam and Powers' conversions 1 = 13 2 = 50 3 = 76 4 = 92 5 = 100
Sex	Sex	1 = Male 2 = Female
Both parents living	BP	Are both parents living? 1 = No 2 = Yes
Living with both parents	2P	Are you living with both parents? 1 = No 2 = Yes
Immigration status		Where was (child, mother, father) born
Child's birth place Mother's birth place Father's birth place	CB MB FB	1 = U.S.A. 2 = South/Central America 3 = Europe or Canada 4 = Asia 5 = Africa
First-generation students	f1	CB = <1
Second-generation students	f2	CB = 1 and MB or FB = <1
Third-generation students	f3	CB = 1 and MB = 1 and FB = 1
Ethnicity	Eth	1 = White, Caucasian 2 = Puerto Rican, other Latino 3 = Black, Negro, African American 4 = Asian
If Asian	AS	1 = Japanese 2 = Chinese 3 = Southeast Asia (Korea, Vietnam) 4 = Indian (India, Pakistan) 5 = Pacific Islands (Philippines, Hawaii, etc.)

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CHAPTER 3

EARLY IDENTIFICATION OF MATHEMATICS TALENT HAS LONG-TERM POSITIVE CONSEQUENCES FOR CAREER CONTRIBUTIONS

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Abstract

This chapter begins with a description of the Olympiad program in the United States and then proceeds to present the results of a retrospective study of the American Math Olympians. The chapter is organized around two basic research questions: What factors contribute to or hinder the development of the Olympians' math talent? Do the Olympians fulfill their potential? The results of this study show that 42% of the American Olympians earned Ph.D. degrees (an additional 13% are enrolled in Ph.D. programs), and many are successful in business fields. In terms of productivity, these Olympians are responsible for the publication of 15 books, 435 articles, 274 research papers, and 15 patents. Several factors, especially family influences, are shown to contribute to the development of the Olympians' talent. Hindrances experienced by the Olympians are also implicated, particularly those dealing with their social development.

Description of American Olympiad Program

The Americans use three tests to identify Math Olympians. In 1995 the first mathematics achievement test (American High Mathematical Examination — AHSME) was administered to 350,000 students. Those scoring above a certain cut-off point (15,000–20,000 students) were invited to take the second exam (American Invitation Mathematical Examination — AIME). From this testing, the top 140 students were selected for the third exam.

The top six scorers (plus two alternates) are identified as Math Olympians. Overall, these final eight students are the top 0.002% of those originally tested. The eight Math Olympiad winners are invited to attend the Math Olympiad Summer Program (MOSP), which lasts four weeks. This training prepares the Olympians for the international competition.

The costs of the programs are very modest with a school's registration fee ($15.00) and a charge for each student tested ($.75). If a school tested their top 10 math students, the total cost to the school would be $22.50 ($15.00 + $7.50). Despite these low costs, only 25% of American high schools participate in the program (5,495 high schools). The Math Olympiad program also

conducts a junior high school program in which only 10.7% of the schools participate (3,000 schools).

Methods and Procedures

As mentioned in Chapter 2, questionnaires were developed for the Olympians, and separate questionnaires containing parallel information were developed for their parents. This procedure was used to make sure that the information provided was accurate and truthful. In essence, this approach was used to ensure the validity of the information by building in a way of verifying much of the data.

The parents were mailed a 12-page questionnaire together with a copy of the 4-page Inventory of Parental Influence (IPI); the Olympians were mailed a 16-page questionnaire along with the Self-confidence and attitude attribute Scales (SaaS, 5 pages). Both questionnaires contained many blank spaces that the participants used to add in-depth information.

Three waves of mailing were used together with phone calls and internet contacts. The mailing took place over an eight-month period. Packets were mailed to the parents of the most recent Olympians and to the parents of older Olympians who supplied us with their addresses.

Since the inception of the Math Olympiad program in the United States (1972), there have been 135 individuals selected (133 males, 2 females). Library citation searchers and repeated mailings, both to the Olympians' homes and former university addresses, proved ineffective in finding 35 of the Olympians. There were four Olympians living overseas in Asia and Europe. One replied from Turkey, but the other three were impossible to locate. Two Olympians have died, and two declined to participate. The sample, then, consists of 94 Olympians with valid addresses. The response rate from these Olympians was 77% (72 usable replies), and from their parents the response rate was 89% (55 parents replied from a sample of 62 parents' addresses).

The age breakdown of the sample consists of three cohorts. The youngest cohort (ages 15–22) contains 23% of the sample. These individuals are either still in high school or in college. The middle cohort (ages 23–29) consists of 35% of the sample and is characterized by Olympians enrolled in advanced degree programs. The oldest cohort (ages 30–41) contains 47% of the sample and represents mature Olympians who are employed in different occupations.

Quantitative Results

The research questions for the studies are listed in Chapter 2. The full set of questions can be summarized by two basic questions: 1. What factors contribute to or impede the development of the Olympians' math talent? 2. Do the Olympians make contributions to their fields? (Do they fulfill their potential?)

Family Background Factors

Does a family's background play any role in the development of an Olympian's math talent? Does ethnicity, religious affiliation, or immigration status have any effects?

According to U.S. Census data, the ethnicity of American students (ages 5–17) breaks down

Table 3.1
Descriptions of Math Olympians in U.S.

Olympians		Parents	
Ethnicity (%)			
Caucasian	84		86
Asian Am.	16		14
No answer	(5 Olympians)		
Religion (%)			
Protestant	18	Protestant	43
Catholic	9	Catholic	11
Jewish	20	Jewish	31
None	42	None	11
Other	5	Other	4
No answer	5		
Family size—number of children		1.42 children/family	
Age span between children		5.27 years	
Birth order (%)			
Olympian 1st child	66		
Olympian 2nd child	20		
Other	13.5		

24% of the Olympians have distinguished relatives; 30% of their relatives won awards.

into the following: 67.6% Caucasian, 15.8% Blacks, 12.7% Latino, 3.8% American Indians or Asian Americans (NCS, 1995). The Olympiad sample contains more Caucasians (84%) and far more Asian Americans (16%) than the general population of American students (see Table 3.1). Furthermore, there are no Blacks or Latinos in the sample. Among the youngest cohort, the percentage of Asian Americans jumps to 31%.

In terms of religion, most of the Olympians specified no religious affiliation (42%). Twenty percent of the sample were Jewish, 18% were Protestant, and 9% were Catholics. These percentages do not reflect the affiliations of most Americans. The U.S. Census reported 66% of the population to be Protestants, 26% Catholic, 3% Jewish, 3% listed as none, and 1% as other (U.S. Bureau of the Census, 1994). Therefore, there are many more Jews among the Math Olympians and more who specify no religious affiliation at all.

Terman (1922) reported an "excess" of Jewish cases among the 1,000 gifted children he identified and followed over the course of their lives. Roe (1952), in a study of 64 eminent scientists, found no Catholics, five Jews (8%) and the others from Protestant backgrounds. Only three of these scientists (5%) maintained a serious religious activity in their adult years.

Fourteen percent of the Olympians are first-generation Americans, and another 18% originate from foreign born parents. The U.S. Census reports immigrants as 7.9% of the U.S. population (U.S. Bureau of the Census, 1994). Thirty-two percent of the Olympians or their parents immigrated to the U.S. from Asia, Israel, Europe, or the former Soviet Union. The foreign character of these Olympiad families is evident from the high percentage of homes (54%) that reported speaking one or more foreign languages.

The fact that disproportional numbers of Jewish and Asian Americans are found among these Olympians may be due to the high regard with which scholarship and learning are held in the Jewish and Asian cultures (see Campbell, 1995). Roe (1952) found that the families of prominent scientists emphasized "learning for its own sake." Bloom (1985) called this quality an intellectually stimulating home environment.

The underrepresentation of females and minorities among the Olympians has also been found by others (Benbow & Stanley, 1983a, b; Fiengold, 1992a, b; Terman, 1922). Campbell and Beaudry (1996) believe that these findings are the result of traditional differential socialization patterns that effect the way males and females are socialized into their definitive sex or minority roles.

Two-thirds (66%) of the Olympians were the first-born child in small families (1.42 children) where the age span between siblings was 5.27 years. In Roe's study, 61% of the eminent scientists were the first-born child, and the age span between siblings was five years. Other research studies with gifted children also indicate small families, wide spacing of siblings, and first-born status for the gifted child (Walberg & Marjoribanks, 1976; Walberg & Starhia, 1992).

Socio-economic Factors

Are socio-economic factors important in nurturing academic talent? Are the Olympians the product of affluent families? Many of the American Olympians came from well-to-do families (see Table 3.2). The mean income was $68,050. Most of the Olympians owned their own home (85%), owned a car (91%), a TV (95%), and a stereo (84%). In terms of intellectual resources, 92% owned reference books, and 78% owned a set of encyclopedias. However, some of the Olympian families had more modest incomes.

Most of the Olympian families (51%) had incomes that exceeded $50,000, but 33% had family incomes between $25,000 and $49,999, and 16% had incomes below $24,000. The immigrant families could be expected to have the lowest incomes.

The parents of the Olympians had much higher levels of education than most American students (see Table 3.3). Many of the fathers (48%) and some of the mothers (11%) had MD, Ph.D. or JD (doctor of law) degrees, and most of the fathers (99%) and mothers (68%) had college degrees. The occupational status of both parents was also high with many fathers and mothers having professional occupations. In Terman's (1922) study, 50% of the fathers had professional occupations, and in Roe's study, 53% of the scientists came from families with professional fathers. Combining occupational, educational attainment and income data, it must be concluded that the Olympians' families had relatively high levels of socio-economic status.

Surprisingly, 70% of the Olympians played an instrument when they were growing up. In high school, 50% played an instrument, and 28% currently play.

Table 3.2
Olympians Socio-economic Data Own (%)

	Olympians	Parents
TV	95	90
Car	91	96
Stereo/Radio	84	89
References	92	
Encyclopedias	78	74
House	85	85
Apartment	7	15
Income	M $68,050*	M $68,020**

*40 olympians responding, **45 parents responding.

Table 3.3
Parents Occupations and Education

Olympians		Parents	
Parental occupations (occupational status)			
Father		Father	
M	83.85	M	87.7
S.D.	19.46	S.D.	13.38
Mother		Mother	
M	85.61	M	91.91
S.D.	19.94	S.D.	10.61
Parental educational attainment			
Father		Father	
M	92.05*	M	92.96
S.D.	17.03	S.D.	12.93
Mother		Mother	
M	90.11**	M	88.48
S.D.	17.52	S.D.	12.65

*Mode, M.D. Ph.D. Lawyer.
**Mode, college graduate with some graduate school.

School Factors

When the Olympians go to school, what factors contribute to or inhibit the development of their math talent?

Most of the parents of the Olympians discovered their child was gifted (85%) before the beginning of formal schooling. Some families (13%) came to this conclusion during the elementary school years, and 2% of the families came to this conclusion during the Olympians' junior high school years.

In the United States, 89% of the schools are supported by public funds. The remaining 11% of schools are religious or nonreligious private schools. Most Olympians attended public schools (82.4%); 13.5% attended nonreligious private schools; 2.7% attended religious private schools; and the remainder attended both types of private schools. Forty-three percent of the Olympians were enrolled in gifted classes during the elementary school years; 56% in the junior high school years; and 57% during the senior high school years.

Did the schools, with their spotty record of providing gifted classes to these talented individuals, inhibit their development? This question was especially crucial for the 57% that were enrolled in regular math classes during the elementary school years. (In another section of this chapter more information will be provided about the Olympians' views about their experiences during these years. These qualitative data add an interesting dimension to their early school experiences in math classes.)

The Olympians scored low on the school hindrances scale, indicating that they did not experience many hindrances ($\bar{X} = 2.03$, SD = 0.87). One of them commented, "If we were hindered by these factors, we would not have become Olympians." The Olympians' parents reported significantly more hindrances than their children, but even their scores were not high ($\bar{X} = 2.49$, SD = 0.99). To some extent the parents worked to overcome any hindrances that occurred in school. Some moved to different neighborhoods so that their gifted child could have better opportunities at school. Others confronted school administrators in an attempt to secure books and other resources to use with their child.

Family Processes

Do specific family processes inhibit or contribute to the development of math talent?

Campbell (1994a) and his colleagues developed international factor scales that isolate five family processes: pressure, psychological support, parental help, press for intellectual development, and monitoring/time management. With these scales, data have been collected concerning these five family processes from parents in China, Thailand, and the United States. This international data can now be compared with the data derived from the Olympians' parents (see Table 3.4).

The Olympians' families reported using the least pressure during the children's school years (effect size (g) = –1.00). Parents tried not to use pressure as a motivating force during the Olympians' developing years. Low levels of pressure have been associated with higher achievement in a number of studies (Campbell, 1994b; Campbell & Uto, 1994; Campbell & Wu, 1994; Flouris, Calogiannakis-Hourdakis, Spiridakis, & Campbell, 1994; Pittyanuwat & Campbell, 1994).

Instead, the Olympians' families provided much more psychological support (g = 0.64) than any of the other international samples of boys. This combination of high support and low pressure has been found to be positively related to the development of the different academic self-concepts (math, science, social studies, languages) and to either directly or indirectly affect academic achievement (Campbell, 1994b; Campbell & Wu, 1994; Flouris et al., 1994; Pittyanuwat & Campbell, 1994).

The Olympians' families also reported supplying more resources (g = 0.77), less help (g = –0.78) and less monitoring (g = –0.10) than the other international samples. Again, these processes have been found to be directly related to higher levels of achievement.

Overall, the Olympians' families supplied higher levels of psychological support and intellectual resources and low levels of monitoring and the least pressure and help. These combinations would provide a stimulating, supportive environment for the development of talent.

Another scale measured the conducive atmosphere in the home. This scale has not been used with other international samples. It is noteworthy that the parents' perceptions of the home atmosphere ($\bar{X}$ = 3.52, SD = 0.77) were significantly higher on this scale than the perceptions of the Olympians ($\bar{X}$ = 3.10, SD = 0.80).

Table 3.4
Family Processes (U.S.)

Pressure	M	1.91
(Parents' perceptions)	SD	.55
Psychological support	M	4.15
(Parents' perceptions)	SD	.45
Parental help	M	2.72
(Parents' perceptions)	SD	.79
Press for intell. dev.	M	3.94
(Parents' perceptions)	SD	.86
Monitoring	M	2.49
(Parents' perceptions)	SD	.91

Self-concepts/Attributions

How confident are the Olympians generally (general self-concept) and how confident are they in terms of their academic abilities (math, science)? Do they attribute their failures or their successes to their ability or to the expenditure of more effort? In answering these questions the Olympians' scores were compared with those of other national and international samples that have used the same scales (see Table 3.5).

Table 3.5
Olympians' Self-concepts and Attributions (U.S.)

Math Self-concept	M	4.59
	SD	0.55
Science Self-concept	M	4.44
	SD	0.61
General Self-concept	M	3.98
	SD	0.71
Effort Attribution	M	3.21
	SD	0.62
Ability Attribution	M	2.91
	SD	0.58

The American Math Olympians have a higher level of confidence in their math and science abilities than any of the other samples of males tested in the international studies. These comparisons include 13 samples of male students from international and U.S. studies of elementary and secondary school students. Eccles, Ader, Futterman, Goff, Kaczala, Meece & Midgley (1983) have shown that the academic self-concepts fluctuate from grade school to high school. The international data with math self-concept verify this finding. The math self-concepts of the Olympians exceed the math self-concepts of the other samples of high school students by a large margin ($g = 1.79–2.12$). Similarly, the high school males were found to have more confidence in their math abilities than the males in the eight elementary school samples.

The Olympians were more confident in their science abilities than any of the other high school samples but the differences were not as extreme as for math ($g = 0.35–1.70$). They were also more confident in their overall ability (general self-concepts). In terms of attributions, the Olympians attributed effort to be more important in their successes than ability.

High School Productivity

How productive are the Olympians during their high school careers? Do they win other awards? Are they involved in extracurricular activities, or are they "loners"?

The Math Olympians were exceptionally productive in terms of high school grades. Twenty-four percent were the valedictorians of their high school graduation classes, and 63.5% graduated within the top 10 ranks. Many of the Olympians graduated from high school at 16 years old (17%) or 17 years old (48%), which would indicate some acceleration during their academic careers (Table 3.6).

In order to isolate the report card grades that the Olympians achieved during their high school

Table 3.6
Olympians in U.S. High Schools

	Olympians			
Rank in graduation class: (%)				
1st	24.3			
2nd	5.4			
3rd	32.4			
Age at high school graduation (%)				
15				
16	17			
17	48			
18	28			
19	3			
20	3			
Grades in high school (Scale: highest score 7; lowest score 1)				
	Math	Science	English	Social Studies
M	6.99	6.90	6.50	6.40
Mode	7	7	7	7
SD	1.8	1.8	1.9	1.9
	SAT-V		SAT-M	
	M 681		796 (52 perfect scores)	
	SD 285.9		320.5	

64 Olympians responding.

careers, items developed for the Longitudinal Study of American Youth (LSAY), were used. These items listed seven groupings of letter and numerical grades. The Olympians reported their math and science grades to be mostly As; for English and Social Studies they reported A-grades. Their Scholastic Aptitude Test (SAT) scores were exceptionally high with an average math score (SAT-M) of 796 (maximum score 800) and an average verbal score (SAT-V) of 681. The average total score of both parts of the SAT was 1,477. (For the math portion of this test, 52 of the left Olympians had perfect scores.)

The SAT test is administered nationwide in the United States as one of the college entrance exams. In 1990 the national means for the SAT-V was 424 and for the SAT-M it was 476. The national average SAT total score was 900 (Profiles, college-bound seniors, 1991). The top 10th percentile for the 1990 SAT was 585 for the SAT-M and 512 for the SAT-V (total 1,097). The Olympiad SAT scores would place them in the top 1% for math and the top 3% for verbal.

Most of the Olympians (84%) enrolled in advanced placement courses in high school. The average Olympian took 3.2 advanced placement courses. This small number of students won 169 awards during their high school careers including 71 National Merit Awards and nine Westinghouse Talent Search Awards. One Olympian was a National Finalist in the Junior Science and Humanities Symposium contest, and eleven Olympians participated in the Johns Hopkins University Study of Mathematically Precocious Youth program.

Most Olympians (76%) participated in extracurricular activities. Some of the extracurricular activities listed by the Olympians included the chess club, mathletes, chorus, drama, literary magazine, school newspaper, student government, National Honor Society, Junior Academy, church youth group, computer club, baseball, track, basketball, soccer, and tennis. This high level of participation, coupled with the Olympians' numerous awards, dispels the commonly

held stereotype of the high achiever in mathematics as an isolated "loner." Other studies (Campbell 1985, 1988; Terman, 1954) found exceptional students to be well-rounded and active in most after-school activities.

Olympiad Program

Did the Olympiad program help the Olympians further the development of their math talent? The Olympians and their parents are in the best position to answer this question. Both the Olympians (76%) and their parents (70%) expressed the view that they would not have accomplished as much without the program. When asked if the program helped or hindered their acceptance of their talents, 76% of the Olympians and 74% of their parents concluded that the program helped. Only 4% of the Olympians and none of the parents thought it hindered the development of their talent in any way. Most Olympians (76%) and their parents (83%) reported that the program helped to increase their awareness of educational opportunities. Participation positively changed 65% of the Olympians' attitudes toward math (Table 3.7).

Eighty-one percent of the Olympians and their parents said the program changed others' attitudes toward them. However, intensive summer training sessions had some limited negative consequences on 43% of the Olympians, and 16.2% reported some degree of burn-out.

College

What factors in college helped or hindered the development of the Olympians' math talent? The Olympians were accepted in the elite American colleges and universities. One Olympian

Table 3.7
Olympians' Assessments of Olympiad Program (U.S.)

	Olympians	Parents
Would Olympian have accomplished as much without the program? (%)		
Yes	24	30
No	76	70
Did the Olympiad program make Olympian aware of educational opportunities? (%)		
Very well, some	53	72
Little	23	11
None	23	17
Participation in program changed others' attitudes toward Olympians: (%)		
Positive changes	81	81
No change	12	11
Negative changes	5	0
Missing	1	8
Participation helped/hindered Olympians to accept their talents: (%)		
Helpful	76	74
Neither helped nor hindered	13	18
Hindered	4	0
Not applicable	7	8

58% of the Olympians believed their training experiences could be developed into a stimulating program for high-ability math student.

was admitted to MIT at 16 and graduated with a master's degree at 19 years of age. Sixty-one percent of the Olympians received scholarships, and their transition to college was relatively easy (3.6 on a scale of 5). The advanced placement courses taken in high school helped the Olympians adjust to college life. Few of the colleges provided special programs (16%) or individualized opportunities (22%) for them. However, 46% of the Olympians reported having undergraduate mentors to aid their development, and 43% received mentors at the graduate level (see Table 3.8).

Table 3.8
U.S. Olympians in College

Olympians		Parents
Transition to college		
M	3.6	3.4
SD	1.7	2.3
College provides special program for Olympian (%)		
Provisions	16	26
No provisions	84	74
College provides individualized opportunities for Olympian (%)		
Opportunities	22	20
No opportunities	78	80
Undergraduate mentor (%)		
Mentor	46	31
No mentor	54	69
72.5% Olympians graduated from college (24% enrolled in high school or college)		
Transition to graduate school		
M	3.9	4.4
SD	2.1	2.3
Graduate mentor (%)		
Mentor	43	30
No mentor	57	70

The qualitative data provided more information about the Olympians' college experience. A few of these talented students were unprepared for college and experienced difficulty (two dropped out). Some Olympians were bored by the lack of challenge, but most adapted quickly to the academic demands. Some were able to skip freshman year and qualify for advanced standing in upper level or graduate courses. However, many of the Olympians reported difficulties in adjusting socially to college life. Such complaints are quite natural for many American students. Colleges and universities that provided flexibility for the Olympians were the most successful in helping them develop their talents.

Computer Literacy

Did the Olympians develop a high level of computer literacy? Does this literacy contribute to their productivity?

The American Olympians reported extensive use of computers. Seventy percent of the Olympians owned a computer and 89% worked day-by-day on a computer. They spent an average

of 14.7 hours per week on microcomputers or 13.5 hours per week on main frame computers (see Table 3.9). They also used a variety of software programs. Most Olympians (71.2%) have e-mail addresses and regularly use either internet or bitnet. The average number of computer languages known by the Olympians was 4.8. The most common languages were Fortran, Basic, Pascal, Mathmatica, Assemblers, APL, C, C++, LISP, Cobol, Logo, REXX, and Tex. On a five-point scale, they rate their literacy as 4.08.

Path Analysis — GPA

What factors contribute to or impede the development of the Olympians' math talent? This basic question was broken down into a series of specific questions that were listed under separate headings. By using a multivariate path analysis, this fundamental question was answered more comprehensively. To accomplish this goal several important factors and variables were combined and analyzed together in a single complex path model. Using the Olympians' high school grade point average (GPA) as the end point (dependent variable), the following predictor variables were used in the analysis: number of awards won (measure of ability), effort attributions factor, motivation (second-order factor containing the math and science self-concept factors), computer literacy factor, two school hindrance factors (one factor from Olympians' perspective; one factor from parents' perspective), positive home factors (second-order factor containing parents' factors of support, help, press for intellectual development and conducive home atmosphere), negative home factor (second-order factor containing the parents' factors of pressure and monitoring), and socio-economic factor (including mother's and father's occupational status, mother's and father's educational attainment levels and the family's income).

Table 3.9
U.S. Olympians' Computer Utilization

Own computer (%)			70
Work on a computer day-by-day (%)			89
Hours per week on microcomputer (61 responding)		Hours per week on main frame computer (41 responding)	
M	14.7	M	13.5
SD	15.8	SD	11.8
Software used: (%)			
PC/MS DOS	28	Macintosh	32
OS 2	1.4	UNIX	8
Other	9.5		
Software programs used (%)			
	Microcomputer	Main frame computer	
Word processing	73.0	35.1	
Math/statistics	36.5	34.0	
Spread sheet	28.4	5.4	
Internet	46.0	49.0	
Database	12.2	9.5	
Games	40.5	11.0	
Graphics	7.0	3.0	
Desktop publishing	20.3	5.4	
Other	18.0		

This analysis focuses upon the Olympians' high school career and the factors that were important in determining their overall high school grades in the four major academic subjects: math, science, English, and social studies. Despite the limited amount of variance available for the GPA variable (Olympians had high achievement in all subjects), the analysis showed that three of the variables had significant path coefficients and six other variables had moderate path coefficients with the dependent variable (see Table 3.10). Olympians with better academic

Table 3.10
GPA Jackknife Path Coefficients and Correlations (N = 80)

Dependent variable	Predictor variables	Direct effect	Indirect effect	Total effect	r with GPA
GPA					
	Factor — Comp. literacy	–0.30*	-0.01	–0.31	–0.24
	Factor — Hindran. Olympians	0.15	-0.07	0.08	0.06
	Factor — Hindran. parents	0.12	0.03	0.15	0.09
	Factor — Mot	0.16	-0.02	0.14	0.13
	Factor — Effort	–0.27*		–0.27*	–0.22
	Factor — Home positive	0.23*	-0.05	0.18	0.09
	Factor — Home negative	–0.11	-0.00	–0.11	–0.11
	Awards	0.13	-0.04	0.09	0.06
	Factor — SES	–0.14	0.06	–0.08	–0.05

*$p<.05$.
R^2= 0.23.

self-concepts in math and science who attained more awards and experienced more positive home influences had higher GPAs.

There were significant negative influences for computer literacy and for effort attributions. Those Olympians with higher computer literacy and higher effort attributions had lower achievement. Those students who spent the most time with computers had lower grades because computer literacy has no connection with any of the high school academic courses that comprise the GPA. The most computer literate Olympians were spending considerable amounts of time working on computers to pursue their own interests.

The path model showed that SES had strong, statistically significant effects on the families' positive home atmosphere (0.37). High SES families had much higher levels of positive home influence.

Productivity

Do the Olympians make contributions to their fields? Do they fulfill their potential? These questions are answered by following the Olympians through their college years to graduation, into their graduate training, and finally on to their professional careers. One measure of productivity involves the enrollment in the most selective colleges and the completion of college/universities degrees. The Olympians were successful in enrolling in the most prestigious colleges/universities in the United States (see Table 3.11). The 20 institutions listed in this table constitute the most elite in the nation. The top five (Harvard, Princeton, MIT, U.C. Berkeley,

Table 3.11
Olympians' Colleges and Universities

Number enrolled: Undergraduate	Colleges/ universities	Number enrolled: Graduate
15	Harvard	11
12	Princeton	4
5	MIT	10
3	U.C. Berkley	9
2	U. Chicago	5
2	U. Illinois	5
5	Cal. Tech. Stanford	4
3	Duke	
2	Swathmore	
2	Carnegie Mel.	2
2	Yale UCLA	2
1	Cambridge (U.K.)	1
1	Cornell	2
2	Rice	
	U. Michigan	1
	Johns Hopkins	1
	Northwestern	1
1	Columbia	

University of Chicago) absorbed most of the Olympians and provided them with sound foundations for their careers. With their high GPAs and exceptional SAT scores, it is no surprise to find the Olympians at such institutions.

Four percent of the Olympians completed their undergraduate degrees in two years; 19% in three years; 73% in four years; and 4% in five years. One measure of productivity involves earning advanced degrees. The extent of the Olympians' graduate training is evident from the graduate institutions listed in the table. The same selective colleges are listed at the graduate level. Thirty-one Olympians completed their Ph.D. or law degrees (42%). In addition, eight Olympians are currently enrolled in doctoral programs. If all of these individuals complete their advanced degrees, 55% will have earned their doctorate degrees. Among the doctorate degrees there are two law degrees. Terman (1954) found that 26.3% of 800 gifted males had their doctorate or law degrees. The average time the Olympians take in getting their doctorate degree is 8.57 years from their high school graduation year. The shortest time any Olympian earned a doctorate degree was 6 years; the longest was 13 years.

Most of the Olympians remain in academics, teaching at colleges or universities or doing research. Some gravitate to science and engineering careers, a good number are employed in computer areas, and still others are employed in the business sector (see Table 3.12).

How successful are the Olympians in the business sector (noncollege/universities)? There is no way to determine the contribution made by the Olympians in the business community, but the job titles indicate a number of responsible positions. The most successful might include the five Olympians employed by financial institutions on Wall Street. One was an executive at the prestigious Salomon Brothers, one was a bond trader, and two were financial analysts with major banks. One of these individuals was in charge of the research on derivatives. One of the lawyers was the council for the mayor's office in one of the largest cities in the U.S.

There are several Olympians employed in the computer industry. Two Olympians founded software companies. One is currently the CEO of his company, and the other remains an executive with his company. Another Olympian is the executive director of a nonprofit corporation.

Table 3.12
Olympians Occupations (not in Colleges and Universities)

Number	Occupation/job title
7	Scientists/engineers (including 1 Principal Engineer with 9 patents, 1 at Los Alamos Nat. Lab, 1 at Bell Labs (ATT) 1 at IBM)
5	Wall Street (2 financial analysts, 1 bond trader)
3	Computer programmer/analyst
2	Lawyers
2	Teachers (authors of text books)
2	Computer music companies
2	Founded software companies
2	Talmud Scholars
1	Computer programmer/algorithm designer
1	Software developer
1	Consultant — scientific programmer
1	Software company executive
1	Executive Director of Nonprofit Corp.

A number of Olympians are scientists or engineers. One is a principal engineer with nine patents, another is a scientist at Los Alamos National Laboratory, another is a scientist at the Bell Laboratories (AT&T), and still another is a senior scientist at IBM.

Two of the Olympians are Talmud scholars. The two teachers co-authored two textbooks. Another Olympian founded a journal that is in its ninth year. One Olympian performed with a musical ensemble at Carnegie Hall.

The majority of Olympians, however, are employed at colleges or universities. How many publications have they produced? Table 3.13 contains the output data for these Olympians. The

Table 3.13
U.S. Olympians' Academic Productivity

Academic productivity	
Articles published	435
Books published	15
Research papers presented	274
Patents	15

Olympians have published 435 articles, 15 books, 274 research papers, and 15 patents. The bulk of these publications was done by Olympians in their thirties or forties. This finding makes sense in light of the time it takes to secure a doctorate degree and the difficulty junior faculty encounter in getting articles and papers accepted for publication.

In many technical areas there is the belief that breakthroughs come largely from young researchers (Lehman, 1953). The Olympians' publication activities fit the pattern that Terman found in his monumental longitudinal studies. Terman (1954) recorded the publications of 67 books and 1,400 articles and research papers for 800 gifted males. The average number of publications was 1.9 publications per person; for the Math Olympians the rate is greater at

9 publications per person. It must be emphasized that 46 of the Olympians are younger than 30 years old and can be expected to publish articles, books, papers, and secure patents. The oldest cohort (ages 30–41) can also be expected to continue their productivity.

One factor involved in this high level of productivity is the mentoring done during the Olympians' undergraduate and graduate years. The disparity between Olympians who have been mentored and those who were not mentored is startling (see Table 3.14). The majority of all

Table 3.14
Academic Productivity in Terms of Mentoring

	Mentored Olympians	Non-mentored Olympians
	$N = 46$	$N = 27$
Articles published	401	34
Books published	14	1
Research papers presented	252	22
Patents	12	3

different types of publications was done by those who were mentored. Ninety-two percent of the books, articles, and research papers were produced by mentored Olympians as were 80% of the patents. Summarizing the output of these academic Olympians, it can be concluded they have been exceptionally productive. The 724 publications and the 15 patents represent an important contribution. Most of the academic and business sector Olympians have fulfilled their potential.

Path Analysis — Productivity

Just as it was possible to do a path analysis on the Olympians' GPA, it was possible to do another path analysis on the factors that contributed to their academic output (i.e., articles, books, and research papers). For this analysis a productivity factor was created out of each individual's output in terms of articles, books, and research papers. This factor was the dependent variable in the analysis where the following predictor variables were used: effort attribution factor, computer literacy factor, GPA, motivation (second-order factor including the math and science self-concepts), "ment" (whether mentoring was provided), two school hindrance factors (from parents' and Olympians' perspectives), positive home factor (second-order factor), negative home factor (second-order factor), age, and SES factor.

The path analysis uncovered one significant and two other variables having modest influences on the Olympians' publications (see Table 3.15). The largest is age (0.51). This variable is highly correlated with mentoring ($r = 0.40$) and gains credit for most of the productivity variance. When age is eliminated from the analysis, mentoring emerges as a significant influence (0.22). The mature Olympians wrote the most articles, books, and research papers.

The next most important factor is effort attribution (0.17). Olympians who expressed higher effort attributions produced more articles, books, and research papers. Computer literacy was negatively related to productivity (–0.16), which indicates that Olympians in the computer area do not publish extensively. In fact, many of the most computer literate individuals are employed outside academia where publications are not central to promotion.

Table 3.15
Academic Productivity Jackknife Path Coefficients and Correlations ($N = 80$)

Dependent variable	Predictor variables	Direct effect	Indirect effect	Total effect	r with Acad. Prod.
Academic productivity factor	Ment	0.07		0.07	0.32
	Factor — comp. Literacy	-0.16	0.01	-0.15	-0.11
	Factor — Hindran. Olympians	0.03	-0.01	0.02	-0.19
	Factor — Hindran. Parents	-0.09	-0.00	-0.09	-0.19
	GPA	-0.03	0.00	-0.03	0.03
	Factor — Mot.	0.01		0.01	0.17
	Factor — Effort	0.17	0.01	0.18	0.16
	Factor — Home Positive	0.02	0.03	0.05	0.05
	Factor — Home Negative	-0.09	0.02	-0.07	-0.20
	Age	0.51*	0.02	0.53*	0.52
	Factor — SES	0.13	0.00	0.13	0.07

*$p<.05$.
$R^2 = 0.38$.

The last significant influence was the Olympians' SES. The Olympians that came from higher SES families had the highest level of academic productivity. With so many of the Olympians' parents employed at colleges and universities, it makes sense that this background would be a stimulus to the Olympians' publication activity.

It should be noted that GPA was not found to be an important variable for productivity, nor were the math and science self-concepts. The Olympians' effort attributions were influenced by the positive home influence factor (0.21).

Qualitative Data

The comments, reactions, and statements made by the Olympians and their parents were the source of 10 themes (see Table 3.16). These themes contain information that goes beyond the quantitative data. Some of these themes tie into the research literature dealing with the gifted and others break new ground. For some themes, lengthy quotations are included whenever the message conveys especially important ideas. For other themes, the thoughts of the Olympians and their parents are paraphrased. Some of the themes contain many examples, others are brief and to-the-point.

Delayed Recognition

The Olympiad program had some profound effects on the Olympians. When asked to comment on what the Olympiad experience meant to the participants, 66 responded with lengthy statements. Most of the Olympians had supportive families that nurtured confidence in their abilities, but to score in the top six or eight places in a national math exam was a more important milestone for their confidence. They described their reactions to this achievement in these ways:

Table 3.16
Qualitative Themes

Title	Description
1. Delayed recognition	Olympians recognition of their potential
2. Learn-on-your-own/ importance of books	Some Olympians learn to read on their own and many learn to read math texts like others read novels. This capacity enables the Olympians to explore many topics that interest them
3. Learn how to turn negatives into positives	Olympians capability to reverse negative school experiences and turn them into growth experiences
4. Think-for-yourself (Autonomy)	A by-product of learning-on-your-own. Especially useful in solving challenging math problems
5. Flexibility	Teachers learning how to let exceptional students to tutor others or to let them learn-on-their-own
6. Resourceful parents	Parents recognize a lack of opportunities and intervene proactively
7. Social relations	Hostility to the gifted may originate from the gifted themselves. Counseling recommended to prepare them for dealing with ordinary people
8. Need to be challenged	Basic problem for the education of exceptionally talented students
9. Need for internal motivation	Source of the Olympians drive for excellence
10. Intellectual atmosphere	Critical home/school atmosphere needed for growth

"confirmation of my abilities," "realization I had potential," "confidence booster," "discovering I had the right to believe in my own abilities," "a chance to be recognized," "made me aware, for the first time, that my math talent was really unusual," "validating," "confirmed my merit," "a more objective indication of my talent," "It helped me gage my talent," and "first indication I had of how good I really was."

This theme is titled "delayed recognition" because so many of the Olympians did not realize the extent of their talent. Some of them had undervalued their capabilities and had set more modest goals for themselves. Their high scores supplied them with much more confidence in their abilities. It also helped them to evaluate their potential more realistically and to set higher goals for themselves. The program also had several other benefits. After announcing the results of the exams, the Olympians were invited to an intensive summer training program (MOSP). This training brought the Olympians in contact with other bright students and exposed them to stimulating presentations by well-known mathematicians. The effects of being exposed to equally bright peers had especially beneficial effects. One of the side effects of the national training program was to alert the Olympians to a select number of colleges and universities where their talents could be optimally developed. This socialization was somewhat responsible for so many of the Olympians enrolling in Harvard, Princeton, MIT, and U.C. Berkeley. The intensive summer program also taught the Olympians more math.

The next five themes are intertwined. They are, in essence, multivariate themes because of their interrelations. For example, "learning-on-your-own" (Theme 2) can occur as a result of learning how to turn negatives into positives (Theme 3). "Parental resourcefulness" (Theme 6) can have interconnections to both of these themes. Likewise, "autonomy" (Theme 4) can occur as the result of Themes 2 and 3. Finally, Theme 5, "flexibility," can occur as teachers respond to the other themes. There are many different combinations.

Learn-on-your-own/Importance of Books

The Olympians have a strong belief in developing a self-taught orientation. Many of them reported learning much of their math "on-their-own" from books. This dependence on books represents an important value for them. The origin of this value can be traced back to practices used by their families during their earliest years. The Olympians' families had high levels of literacy and socialized their child into a "love of books" at very early ages. During the earliest years the parents read to them when they were very young. One parent felt that these early readings enabled the "child to begin making pictures in his mind." This mental imaging also teaches the child the potential that can come from books — the excitement and the stimulation.

The young gifted child in mathematics also needs to have "plenty of manipulable toys during early childhood." Several of the parents emphasized their use of puzzles with their young child. One mother remembered spending "lots of time working puzzles, playing games, reading, and teaching card games." Another taught her child an algorithm (number sticks) for counting, and another mother played counting games with her Olympian between the ages of two and three. Some parents reported that their child at age 4 could "do complex computations in his head, like long division . . ." One father taught his four-year-old boy "basic arithmetic." Some fathers played chess with the developing Olympians, and others taught different math concepts to them. One mother summarized her strategy in this statement:

> Our child's math talent was developed first at home. He was provided with basic math workbooks when we realized his interest and potential. This started around the age of three when we realized he had taught himself to read.

Notice the resourcefulness of this parent in researching books that were available, evaluating them, and then buying the best for her child's development. She also helped to enroll her son in a gifted private school (Grade 2) and in a gifted magnet school (high school). Many of the Olympians could read even before they started school, and the rest learned to read very quickly in the early grades. Therefore, they could understand the math textbooks that were used in later grades. Many of the Olympians found these advanced textbooks to be important sources of stimulation and knowledge. Some read their parents' or their siblings' college math textbooks; others obtained geometry and calculus texts and were able to read them like most people read novels. One of the immigrant Olympians (from Poland) expressed these sentiments in this excerpt:

> I was between 5th and 6th grades and did not know any English, so I had nothing to do other than to browse through the math (and later computer) books we had at home. Within a few weeks, I went from basic algebra to trigonometry, complex analysis, and calculus. Ever since then, most of my math and computer science knowledge has been self-taught.

Many of the Olympians and their parents emphasized the importance of having numerous books available in their homes — not necessarily math books, but books that interest children. The precocious math child needs to learn where to find math books (bookstores, libraries) to satisfy these early interests. Teach them this "skill and they will do much of their learning by themselves." Some Olympians recommended the use of popular math books such as Martin Gardner's math puzzles books (Gardner, 1961, 1987, 1994), *The Lore of Large Numbers* (Davis, 1961), and *Calculus the Easy Way* (Downing, 1988).

Other Olympians expressed the need for publishers to develop more self-study books in math. They felt that they learned so much from self-study that this avenue of learning should be developed and enlarged so that more students could learn on their own. Several Olympians also expressed the need for authors to write more readable "fun-like" math books for the general public.

Many of the Olympian families emphasized the importance of having easy access to a good public library. Such a library must have enough math books for children at different levels of sophistication. The Olympians liked to proceed with such books at their own pace.

Parents, teachers, and librarians need to be aware of the full range of books that are available for young people interested in math. Such books should be made available to the gifted student as they are needed. The more resourceful parents make sure such books are accessible to their young child during optimal times in their academic careers. As the child gets older, the accessibility of a university library becomes a necessity. During the high school years, bright mathematically motivated students need to learn how to answer their questions in technical libraries.

Learn How to Turn Negatives into Positives

Two of the factors developed for the international Math Olympiad studies relate to hindrances found in schools. These factors contain statements describing poor math teachers, insensitive teachers, teachers who did not know their subject, boring math classes, rigid courses, and prison-like atmospheres. Underneath these statements the Olympians were asked to describe any negative experiences. More than 40% of the Olympians made comments about their experiences in school. One expressed the view that "some teachers were patronizing," while "others paid little attention to the more motivated students." Two other Olympians summarized their early elementary experiences in these words:

> I had terrible math teachers in elementary school, so I was unmotivated and I disliked math. I was actually in the bottom math group in my six-grade class.
>
> My elementary school math classes were very, very slow for me. I was bored out of my mind and couldn't motivate myself to do the busywork. I was constantly being punished by the teacher for not doing my homework. If I had not had some more open-minded teachers later on, I might never have gotten into math.

Both of these Olympians were mainstreamed with classmates of much lesser ability and were misdiagnosed by their teachers. Terman (1922) observed that many gifted children were not identified; it was as if they "had worn an invisible cap." Other Olympians felt that many teachers were "clueless" (did not know math); some felt their high school teachers to have an "arrogant disrespect" of their math talents.

However, several Olympians were able to turn these negative experiences into positives. This theme is an important one to emphasize because it is an internal skill that gifted children can develop to overcome the shortcomings that occur in many schools. Several of the Olympians adapted this strategy and, in doing so, were able to foster their own growth. One mother said, "my son effectively did not let any of these things deter him." Here are two examples of how Olympians applied this stratagem:

> None (of these things) hindered the development of my math talent. Actually, I'd say that negative school experiences actually helped slightly in the development of my math talent, in an indirect fashion.
> I had my share of "poor" math teachers (poor in the sense that they did not understand the material), and of boring class work. But the "poor" teachers encouraged me to be a tutor to other students in the class, and if the class work was boring, I moved ahead on my own. (For example, when learning the algorithm for long division in the 4th grade, I went on to prove how it worked, then developed my own algorithm for division.) So I didn't feel hindered.

Think-for-yourself (Autonomy)

One by-product of "learning on your own" is the establishment of a great deal of independence. Children that learn ideas on their own without the aid of teachers or other adults soon become much more independent. Olympians that can pick up calculus on their own or reinvent algorithms for multiplication and division on their own have also achieved a degree of autonomy. This independence becomes more useful in situations where math problems must be solved in imaginative ways. When you have learned much of your math knowledge by yourself, such problems can be viewed as interesting challenges. Fennema and Peterson (1986) believe that such autonomy is developed very early in a child's academic career. The fact that the Olympians mention the importance of this trait reinforces their belief.

Flexibility

Some teachers were creative in seeing the possibility of using the gifted student to tutor other students. This approach helped the less able students but also supplied recognition to the gifted child. With some Olympians, teachers recognized their extraordinary ability and let them learn on their own. Some were handed above-grade-level books and asked to teach themselves the material. This process was used by one second-grade teacher and by many other teachers in different elementary, junior high, and high schools. This approach of letting the exceptionally able student teach him or herself apart from the other students also encourages the development of independence. In Roe's (1952) study, the eminent scientists also preferred teachers that left them alone.

Resourceful Parents

Other Olympians learned most of their math apart from schools. Some of the Olympians were enrolled in after school or summer programs, some attended math classes at advanced grade levels, and others attended math courses at local colleges. One Olympian completed all the math courses offered in his high school before he even attended this school. The summer program mentioned most frequently by many Olympians was offered at Hampshire College. In most cases the parents were responsible for finding out about such outside courses. Parental resourcefulness was therefore used to overcome obstacles erected by the schools or by the lack of programs available in the schools. Parents that can turn negatives around are able to foster greater academic development for their children. This quality of turning negatives into positives

is a skill that should be much more widely used. In point of fact, the schools often fail to see the potential of some students. Why not teach everyone to realize his/her own potential gifts and to figure out ways to develop these talents?

Social Relations

The Olympians and their parents were asked if they experienced any hostility toward their giftedness when they were growing up (see Table 3.17). There was more reaction from the parents than from the Olympians on this topic. For schools without gifted programs, the gifted were mainstreamed with the other children. In elementary schools this left many of the Olympians in a difficult position where they were more advanced (especially in math) than most of the other children. In many cases the other children saw the Olympians as "different." This opened them up to much hostility. Some were teased "unmercifully"; others were "often treated cruelly"; others were harassed or taunted. Some Olympians experienced physical attacks while others experienced psychological intimidation.

During the elementary school years a number of Olympians were not accepted socially by the other children. Some of this hostile behavior was the product of frustration on the part of the more normal children who could not compete with the Olympians. One Olympian summarized this reality in these words:

> A large fraction of students are hostile to a peer for whom a subject (like math) is easy. They feel that they look bad in comparison.

Some of this behavior was simply jealousy, but in other cases the hostility was more serious. One Olympian referred to these negative reactions in these words:

> More frequently I experience ignorance, fear or apathy toward scholastic achievement. (Note the present tense of this statement.)

Another Olympian said, "when I was growing up, I was beaten-up a couple of times for no other reason than because I looked intellectual." Still another expressed the same sentiments: "In elementary school students were jealous of my ability and would tease me when I made occasional mistakes in class. They also treated me as a freak insisting that I demonstrate my knowledge on command." One of the parents also referred to the term "freak" to describe the way other children viewed her son in elementary school. In the United States this term is reserved for circus performers in side-shows such as the "bearded lady" or "the fat man." When applied

Table 3.17
Hostility and Accusations of Elitism

	Olympians	Parents
Hostility toward giftedness reported (%)	39	35
Olympians accused of elitism	22	22

to the gifted, the term denotes a sense of cruelty and viciousness. One parent referred to such treatment as "victimization."

Most of this behavior evaporated during the high school years when the Olympians' other academic talents could be recognized and used both in extracurricular activities and in academic competitions. Many of the Olympians were prized as math tutors or as people who could help other students with their math homework. Some of them were accepted in gifted magnet high schools. For these individuals, the changes were dramatic. One mother described the effect on her son in these words:

> As a youngster his intellectual ability was superior to that of his peers, and he was stigmatized as such. There were no gifted programs on an elementary level, and it was not until high school that he found himself among other bright students. At that time his whole personality changed. He became much happier as he fit in with others on his level, was challenged by them, and found they all had similar interests. As a youngster others made fun of a boy who actually spent his spare time doing math.

Other parents expressed the same reactions as their child finally was enrolled in classes with other gifted students. In the United States there is a movement away from assembling the most gifted students in separate schools or programs, and many of the Olympians commented on this development. In reality, the gifted child needs to experience other gifted children in order to dispel the myth that they are "freaks." They need to learn that their gifts are things that the country needs and can be used to benefit the larger society. The danger of not providing such classes may be to assure the underdevelopment of the gifted students' talent. One young Olympian said, "I have kept my math talent secret as much as possible. I talk about my prior math achievements with nobody, and I fit into society much more smoothly." A mother reported that her son "tried to hide his intelligence" in order "to be more acceptable to his peers."

A number of Olympians placed the blame for much of this hostility on their lack of social skills. The implication is that gifted students, because of their arrogance, literally "ask for it." As one Olympian put it, "no one likes a smart ass." Another Olympian said that much of this problem is due to "a basic lack of respect of others" and "an inability to tolerate those with less talent." Cropley (1993) mentioned the need of counseling for such children. Perhaps these gifted children need to be taught coping skills on how to accept and handle their own giftedness. Many of the Olympians talked about the pain and suffering they experienced in finally attaining these perspectives. One expressed this view in these words: "I acted arrogant and people told me so every couple of days between the ages of 12 and 14. But most precocious math students go through a period of not being able to handle it gracefully. Some grow out of it faster than others. If the math-geek community would work on this a bit, we'd experience much less hostility." This is certainly a problem that educators can deal with. This Olympian touched upon a major point — educators should devote more attention to this facet of the problem. It is probably not possible to change the hostility that is generated by American society toward the gifted, but it is much more possible to help the gifted develop the coping skills that could blunt its effect. Perhaps the parents of these gifted children could be trained to help their children develop such skills. Such training can be viewed as "pain prevention."

Need to be Challenged

One fundamental problem for gifted children at all grade levels is the need to be challenged. Some gifted children adjust their output to the lowest denominator and learn to be lazy with academic work. This need for challenge is an evident theme that is clearly seen by many of

the parents' statements. One mother presented her preschooler with challenging math problems. One of her examples involved cookies: "I might ask a preschool child, if 2 children had 5 cookies and wanted to divide them equally, how many could each child have? If the child thought for a while but wouldn't get the answer, I might give a hint by asking a simpler question: If 2 children had one cookie to divide between them, how much could each have? By the time he was almost 8 he had decided he didn't want hints. He would rather figure out the answers on his own no matter how long it took." This mother's interesting presentations of problems certainly prepared her child for the word problems he would experience during math lessons at school.

The main problem for most bright children is that they pick up the content of the lesson so quickly that they get bored with the repetition that many teachers use to make sure that everyone in the class understands the objective. To solve this problem one elementary teacher periodically gave out brain teaser math problems; another junior high teacher gave one extra-credit challenging math problem each week. In both cases the young Olympians found the practice very beneficial.

Elementary and junior high school teachers need sets of challenging math problems to use with their classes. At the secondary level, challenge can be provided with the different academic contests. Math fairs and interschool mathletes "meets" can stimulate these advanced math students. Schools need to develop programs where students are invited to join math teams or are provided the entrance materials to the different competitions. In some cases the Olympians' parents were responsible for finding nonschool activities that could challenge their child. Several parents isolated outside school activities or summer programs to provide such stimuli.

Need for Internal Motivation

The Olympians excelled in achievement in their high schools. This accomplishment was a product of hard work and several productive attitudes. One important factor in their performance was their high level of motivation. One Olympian believed that motivation was the "determining factor" in his development.

"A motivated student can always find some way to extend himself beyond the material taught in class, whether by asking further questions on his own, or seeking extra material through the library, publications, etc. Bright students who don't do well in school because they're bored need to be taught to not accept learning just what is required, but to always try to learn more than they currently know, however much that is really a philosophy of life. If the parents emphasize always reaching to better oneself (and more importantly, demonstrate this), the student will be much more likely to fully develop this talent."

This "philosophy of life" was an important ingredient for this Olympian. It helped him overcome poor teachers, inadequate curricula, and shortcomings from his schools. This is another powerful coping skill that could be taught to bright students.

Another Olympian referred to this internal motivation as "a passion for mathematics." He felt this passion (uncorrupted by ulterior motivations) "is what is necessary to succeed in almost anything. Moreover, this passion can be developed by talking to people interested in the subject and by reading about it."

Intellectual Atmosphere

Some of the Olympians refer to themselves as intellectuals, and others talk about the importance of an "intellectual community" of students. This intellectual atmosphere refers to a respect for learning and the value of investigating things.

Many of the parents established an intellectual atmosphere very early in their child's life. The heavy dominance of books in the home and the parents' use of these resources provided the children with viable role models for intellectual pursuits.

Once such an atmosphere was experienced at home, the children looked for congruent atmospheres at school. They gravitated to peers with similar backgrounds and thus formed little networks of intellectual peers.

Schools should strive to establish such atmospheres for a segment of the student population. The pursuit of knowledge should be one of the primary goals of any school.

Conclusions

In Chapter 1, the Olympiad program was shown to be only one of several national academic competitions that are held annually in the United States. It can be concluded that this program is very effective in placing talented individuals in the American science and engineering (S&E) pipeline. Any high school program that can boast of having had some influence in 54% of its participants receiving Ph.D./Lawyer (JD) degrees and in the publication of 724 articles/books/research papers and 15 patents must be considered highly successful.

The only other national program that has been partially evaluated, Westinghouse Talent Search, has been associated with five Nobel prizes, two Field Medals, and eight MacArthur Fellowships. What inferences can be made about the other academic contests? Do these competitions fulfil their potential of placing talented students in the S&E pipeline? On the basis of the evaluations of Westinghouse Talent Search and the Math Olympiad program, it is reasonable to infer that these programs accomplish their goals. The academic competitions certainly serve the national interests of America. They represent modest financial investments and pay large dividends for the country.

What factors/variables were the most important in developing the Math Olympians' talent? When considering the quantitative and qualitative findings, the most important factors can be summarized under four headings: Home, School, Olympiad Program, and Mentoring.

Home

The home atmosphere was especially critical in the early development of the Olympians. Most Olympians came from small affluent families where one or both parents were employed in professional occupations. Parents established intellectual atmospheres in their home and learning was highly valued. They also provided a stimulating learning environment by giving high levels of support and low levels of pressure, monitoring and help. Many of the Olympians came from first- or second-generation American families that urge a striving for excellence. Socio-economic

status was important in providing essential resources to optimize the Olympians' development. The parents resourcefulness was an important factor in removing obstacles that hindered the Olympians' development.

School

Olympians had high levels of academic achievement in school, well-developed math and science self-concepts, and strong beliefs in the importance of effort in their achievements. Many of them learned much of their math on their own. They also learned how to overcome ineffective teachers or limitations in the math curriculum by turning these negative experiences into growth opportunities. Schools that treated the Olympians with flexibility had the most success in fostering their development.

Olympiad Program

The Olympiad Program was an important stimulant to the Olympians' development. It helped many of them gauge their potential and funneled them into a select group of colleges and universities where their talent could be better developed.

Mentoring

Mentoring proved to be one of the best policies for tailoring college or university programs to meet the development needs of the Olympians. This practice should be expanded to nurture the growth of a much wider number of talented students.

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CHAPTER 4

GROWING UP IN TAIWAN: THE IMPACT OF ENVIRONMENTAL INFLUENCES ON THE MATH OLYMPIANS

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Abstract

Thirty-six Math Olympians (34 males and 2 females) served as the subjects in a study that asked two questions: (1) What family and school factors contribute to the development of the math talent of the Olympians? (2) What impact did the Olympiad program have on these mathematically talented students? The data were collected by means of questionnaire surveys and in-depth interviews. The major findings were as follows: (1) the Olympians were mostly the first-born child in small families and were "discovered" at an early age; (2) most Olympians ranked high in their class; (3) the SES of the Olympians' families were varied, though the majority were high; (4) the Olympians' family support and learning environment were strong and positive; (5) the Olympiad experiences were, in general, positive for the subjects, especially in learning, forming positive attitudes toward math and science, self-esteem, autonomous learning, and creative problem solving; (6) there were almost no special programs designed for the Olympians during their college years; (7) the degree of computer literacy was varied according to the subject's personal interest and the accessibility to the computer; and (8) most Olympians had not shown special achievement other than math.

Introduction

To watch a little sprout grow to be a big tree is a joy of natural beauty. However, to develop the potential of gifted children is more than this, as it embodies endless hopes and anticipation (Wu, 1992). In Taiwan, due to Chinese cultural tradition and rapid social changes, gifted education and talent development have become one of the top priorities in educational planning in the last twenty years. Among many gifted and talented education programs, the Olympiad Program represents a new type of talent search that has been developed in coordination with International Math/Science Olympiads. In 1991, the first Taiwan team, composed of ten youngsters highly talented in math, participated in the third Asia-Pacific Math Olympiad. One year later, a team of six mathematically talented students attended the 33rd International Math Olympiad. Up to 1995, a total of 48 Math Olympians in Taiwan had the experience of going abroad and competing

(some of them went twice). It is important to know how they were shaped and what the Olympiad experience meant to them. Therefore, this study will answer the following questions:

1. What family and school factors contribute to the development of the math talent of the Olympians?
2. What impact has the Olympiad program had on these mathematically talented students?

Learning Environment and Attitudes

According to Passow (1992), the task for educators is to create an environment that will facilitate students engaging in learning activities that will help them discover their potential and stimulate the pursuit of activities that will nurture this potential. Such a learning environment will require a variety of strategies and structures and will provide a balance between individual and independent study, on the one hand, and cooperative learning situations and group activities on the other (Passow, 1992; Walberg & Wang, 1994).

After studying the lives of exceptionally gifted persons, Pressey (1955) noted that all of these "geniuses" seemed to have (1) excellent and early opportunities for abilities to emerge with encouragement by families and friends; (2) participation with others that provided a basis for continuing stimulating relationships; and (3) stimulation through frequently and increasingly strong success opportunities.

Similarly, from his study of 120 "immensely talented" musicians, artists, athletes, mathematicians, and scientists, Bloom (1985) noted that there was "strong evidence that no matter what the initial characteristics (or gifts) of the individuals, unless there is a long and intensive process of encouragement, nurturance, education, and training, the individuals will not attain extreme levels of capability in these particular fields" (p. 3). He concluded "that exceptional levels of talent development require certain types of environmental support, special experiences, excellent teaching, and appropriate motivational encouragement at each stage of development" (p. 543). The Bloom study found certain values, such as the value of achievement and the importance of doing one's best, was very important in these families.

Based on meta-analysis, Walberg (1984) proposed a Learning Productivity Model which included four environmental factors: home, classroom, peers, and television. He noted that three of them — the psychological climate of the classroom group, enduring affection and academic stimulation from adults at home, and association with an out-of-school peer group that possessed learning-related interests, goals, and activities — influence learning in both direct and indirect ways. Among the out-of-school factors, the home influences are especially powerful.

The learning environment of the Math Olympians thus includes school influences, home influences, and special learning opportunities (the Olympiad activities).

Attitudes consist of cognitive (beliefs or knowledge), affective (emotional, motivational), and performance (behavior or action tendencies) components. With respect to the subject of math, the affective component is related to the feelings of like or dislike for the subject, while the cognitive beliefs refer to the value and utility of math. Both components have been stressed often. The relationship between students' attitudes toward math and their ability in the subject is dynamic and interactive in that individuals with low ability in math are likely to have more negative attitudes toward the subject. Similarly, those with negative attitudes are less inclined to make the effort to improve their math abilities (Aiken, 1985). On the other hand, the active encouragement of parents, teachers, and counselors seems to affect attitudes. A consistent finding of many investigations is that teachers who like math and do

their best to make it interesting can create favorable attitudes and positive student motivation in the subject (Armstrong, 1980). Competition and group projects can also positively or negatively affect students' attitudes toward learning.

Methods and Procedures

The subjects of this study are 36 Math Olympians that participated in either or both the Asia-Pacific and International Olympiads from 1991 to 1994. All subjects and their parents were available. Only two were females. Five (14%) were still senior high students when the data were collected. The rest were all college students majoring in math (18, or 50%), medicine (6, or 17%), electronic engineering (4, or 11%), physics (2, or 6%), or mechanical engineering (1, or 3%). During the four years of participation in the Asia-Pacific Math Olympiad (APMO), the Taiwan Olympians won four gold medals, seven silver medals, and 16 bronze medals. For the three years of participation in the International Math Olympiad (IMO), the Taiwan Olympians won one gold medal, 11 silver medals, and four bronze medals.

The selection of the Math Olympians was based on a national talent search project carried on by National Taiwan Normal University (under the sponsorship of the Ministry of Education). Those who met one of five criteria were eligible to be the candidates (about 70 students for the APMO and 20 students for the IMO). The candidates then participated in a math camp (five days and nine days, respectively) that concentrated on the study of math. During this experience the candidates were observed and evaluated. There were two APMO and six IMO finalists. Since the above procedures were done in February (APMO) and April (IMO), the IMO finalists were mostly from the APMO. Only IMO finalists, however, were asked to attend a semi-intensive training camp for two months, May and June, before going abroad for the IMO competition.

Instrumentation

The instruments used in this study were developed by Campbell (see Chapter 2) for cross-cultural/national studies and included the following: 1. Olympians' questionnaire, 2. parents' questionnaire, 3. self-confidence and attribution scales, and 4. family and school influence scales. The questionnaires/scales were translated into Chinese with minor necessary changes. The basic format of the Chinese versions remains the same as the original.

A semi-structured questionnaire, designed for in-depth interviews in the Taiwan study, included the following themes: 1. family life and parental influences; 2. school life and academic interests, 3. pupil-teacher relationship and teacher influences; 4. peer relationship and social life; 5. learning method/style; 6. extra-curricula activities/interests; 7. "the computer and you"; 8. impressions of the Math Olympiad; 9. opinions of gifted education; 10. brief description of one's self (anything); 11. views about "human life"; and 12. career goals.

Procedures

First, the Chinese versions of the questionnaires/scales were developed and reviewed by two colleagues. Second, the subjects' addresses and basic data were collected with the assistance of

their high school teachers and administrators (the 36 subjects were from 14 high schools, among them 10 were from the renowned Taipei Municipal Chien-Kuo High School). The questionnaires/scales were sent to the subjects and their parents with an invitation letter and small gifts (a pair of pens for the Olympians and a researcher's book concerning parenting, for the parents). All questionnaires/scales were returned in two weeks without further phone reminders. Two parents phoned the researcher, supplying more information and comments.

Twelve graduate students were trained as field interviewers before going to visit the subjects. The targets of the interview were the Olympians, but not limited to them, in case their parents were also available. The interviews were tape recorded and transcribed according to the themes mentioned above. The questionnaires/scales and the interviewing data were completely collected by September 1994. The raw data of the questionnaires/scales were transferred onto scantron pages and machine scored. The quantitative data explained here are descriptive. The qualitative data based on interviews will also be presented and discussed.

Results and Discussion

The results are presented in nine sections. The final section contains a brief summary of the qualitative data.

Family Background

Half (50%) of the Olympians were the first-born child in small families (1.26 children/family) (see Tables 4.1 and 4.2). The socioeconomic status, as determined by the fathers' average occupational status and educational attainment, was much higher than for most Taiwan students. The mean monthly income, $2,931 (Olympians' report) or $2,777 (parents' report), surpassed the average family income in the Taipei area, which is $1,800. According to the parents' reports, most of the Olympians owned their own house or apartment (only two of them were renting), owned a car (61%), a TV (100%), a stereo or radio (100%), reference books (97%), and encyclopedias (72%). On average, there were between 100 and 300 books in the Olympians' home when they were growing up. There were some very slight discrepancies about the family resources reported by the Olympians and the parents, but in general it was evident that most of the Olympians came from professional and affluent families with many intellectual resources. However, some mothers (22%) were homemakers with lower educational attainment (graduating only from elementary school); three Olympians (8%) were from lower SES families with fewer books.

In terms of cultural aspects, most Olympians spoke one foreign language (64%) and two Chinese dialects (75%). While there was only one foreign language (English) taught in school, 14% of the Olympians learned more foreign languages from their parents or from out-of-school programs. Seventy-two percent of the Olympians' family members played instruments, but only 39% of the Olympians played them.

There are connections between SES and childrens' academic performance. However, it is probably the high quality of intellectual stimulation in the home environment (Bloom, 1985) that contributes to children's achievement, not SES itself. Some lower SES families did produce

Table 4.1
Family Background of Math Olympians in Taiwan

Number of families have distinguished relatives:			2 (6%)
Family size: 1.26 children/family (range: 1–3)			
Birth order: 1st child			18 (50%)
2nd child			10 (28%)
Other			8 (22%)
Olympians speak foreign languages			
0 Foreign languages			8 (22%)
1 Foreign languages			23 (64%)
2 Foreign languages			4 (11%)
3 Foreign languages			1 (3%)
Chinese dialects Olympians speak			
1 Dialect			8 (22%)
2 Dialect			27 (75%)
3 Dialects			1 (3%)
Olympians played musical instrument:			14 (39%)
Family members played musical instruments			
0 Members			10 (28%)
1 Members			18 (50%)
2 Members			3 (8%)
3 or more members			5 (14%)
Parental occupations (occupational status)			
		Olympians	*Parents*
Father	M	73.09	73.26
	SD	21.89	21.99
Mother	M	39.47	38.29
	SD	39.41	39.32
Parental educational attainment			
Father	M		77.09
	SD		29.80
Mother	M		60.42
	SD		34.69
Monthly income	M	2,930.83	2,776.90
(US$)	SD	1,257.56	1,151.10

Table 4.2
Socio-economic Resources of the Math Olympians Families in Taiwan

	Olympians	Parents
Books in the home (five-point scale)		
M	4.14	3.75
SD	1.18	1.18
		(Note: 4 = 100–249 books)
Owned (%)		
Motorbike	29 (81%)	28 (78%)
TV	34 (94%)	36 (100%)
Car	24 (67%)	22 (61%)
Stereo/radio	36 (100%)	36 (100%)
References	34 (94%)	35 (97%)
Encyclopedias	22 (61%)	26 (72%)
House	19 (53%)	21 (58%)
Apartment	21 (58%)	19 (53%)

Olympian children, which tend to confirm this conclusion. Therefore, we should pay more attention to other dimensions of the family — the degree of intellectual stimulation supplied and the level of family support.

Schooling

Did the Olympians have special schooling experiences (see Tables 4.3 and 4.4)? Nearly half of the parents of the Olympians discovered their child was gifted (44%) before he or she entered school. Some families made this discovery during the elementary years (22%) or junior high years (25%). Only three (8%) were discovered in the senior high years.

Almost all of the Olympians attended public schools, but only 19% were enrolled in gifted classes during the elementary school years. The enrollment rate increased at the junior high level (36%) and at the senior high school level (75%). That means 75% of the Olympians were selected from talented math/science classes in 14 senior high schools around Taiwan. In Taiwan, programs for the gifted are organized as "special classes" and can be either homogeneous classes with a single teacher or pull-out programs. These programs formally began for elementary schools in 1973, for junior high schools in 1979, and for senior high schools in 1982. To date, there are 68 elementary schools, 35 junior schools, and 19 senior high schools that have special classes for the intellectually gifted or for mathematically/scientifically talented students. In most cases, only the top 2 or 3% of the students in very large schools (exceeding 2,000 students) are selected for these special classes. This means that many mathematically talented students do not receive enriched training or specialized opportunities to develop their talent. However, the special classes do provide stimulating learning experiences and are, in general, enjoyed by the students.

Excluding the five Olympians who were still high school students, about half of the rest of the Olympians (48%) graduated from the high school at the normal age of 18. About half of them (16 or 52%), however, graduated one or two years earlier than non-Olympiad peers. Most of the Olympians ranked above average in the gifted class or were top students in the regular class.

Table 4.3
Schooling of the Math Olympians in Taiwan

Age when parent discovered child was gifted	
Preschool (ages 1–6)	16 (44%)
Elementary (ages 7–11)	8 (22%)
Jr. High (ages 12–15)	9 (25%)
Sr. High (ages 16–18)	3 (8%)
Olympians in gifted classes	
Elementary	7 (19%)
Jr. High	13 (36%)
Sr. High	27 (75%)
Age at high school graduation	
16	2 (7%)
17	14 (45%)
18	15 (48%)
Rank in graduation class	
(22 Olympians were able to response)	
M = 12.04 SD = 11.05	
(Note: Class size varied from 35 to 50)	

Table 4.4
Perceptions of Influences of Home and School

	Olympians		Parents	
	M	SD	M	SD
Conducive home atmosphere	3.14	0.87	3.53	0.73
School hindrances	2.28	1.00	2.81	1.03

Note: Scale	5	4	3	2	1
	Great	Much	Some	Little	Almost none

The Olympians perceived few hindrances in their schools (see Table 4.4). The schooling experience seemed to be positive for the development of their talents.

The Olympians' schooling was somewhat different from that of non-Olympiad students. Their talents were discovered at an early age. However, most of them did not participate in any special programs in their elementary schools or junior high schools. Their families likely assumed the major responsibility in satisfying their special needs when they were young. At the senior high level they did have more opportunities to gain access to a more structured and enriched learning environment, wherein they were selected to participate in the Olympiad program. The impact of schooling on their talent development was, in general, positive.

Family Processes

What is the impact of the family processes, as compared to schooling, on the development of the Olympians' talent? Tables 4.4 and 4.5 show the result. It is interesting to note that parents perceived higher conducive home atmosphere and higher school hindrance than the Olympians (see Table 4.4). In other words, parents seemed to be more satisfied with home than with school in terms of helping their child develop his or her potential. Comparing mothers' and fathers' perceptions, it seemed that the mothers provided more intellectual resources and more monitoring than fathers.

On the basis of these findings, it can be said that families probably play a more important role

Table 4.5
Taiwan Math Olympians' Family Processes

	Mother's perception		Father's perception	
	M	SD	M	SD
Pressure	2.34	0.44	2.49	0.42
Psychological support	4.12	0.47	4.15	0.38
Parental help	3.27	0.83	3.14	0.60
Press for intell. development	3.61	0.61	3.29	0.71
Monitoring	3.79	0.64	3.11	0.62

Note: Scale	5	4	3	2	1
	High		Mid		Low

than the schools in the development of the Olympians' potential. The Olympians' families supplied high levels of psychological support, applied mild pressure, asked for greater intellectual effort, and provided some monitoring and help. These combinations provided a stimulating and supportive environment for the development of the Olympians' talent. The typical Chinese mother in Taiwan usually plays a more important role in educating the child than the father. She often provides a great deal more monitoring and planning, even if her educational background is less than the father's background. She is often anxious about her child's progress. This may be somewhat different from many western countries.

Influences of Math Olympiad Programs

What influences did the Math Olympiad program have on the achievement and attitudes of the participants? Tables 4.6 and 4.7 reveal the following results. About two-thirds of the Olympians felt that without the Olympiad program they would not have accomplished as much. Most Olympians (61%) reported that the program made them aware of better educational opportunities. The parents' favorable opinion was even higher (75%).

Most Olympians (83%) reported positive changes in others' attitudes toward them by participating in the program. Only 6% of the Olympians reported negative changes (the parents did not report any negative changes). Most of the Olympians (83%) said that participation in the program helped them accept their talents. Again, only 6% reported negative side effects.

Table 4.6
Taiwan Olympians' Assessments of Olympiad Program

	Olympians	Parents
Would Olympian have accomplished as much without the program?		
Yes	12 (33%)	16 (44%)
No	24 (66%)	20 (56%)
Did the Olympiad program make Olympian aware of educational opportunities:		
Very well, some	22 (61%)	27 (75%)
Little	10 (28%)	6 (17%)
None	4 (11%)	3 (8%)
Participation in program changed others attitudes toward Olympians		
Positive changes	30 (83%)	32 (89%)
No change	9 (25%)	7 (19%)
Negative changes	2 (6%)	0
Participation helped/hindered Olympians to accept their talents		
Helpful	30 (83%)	32 (89%)
Neither helped nor hindered	4 (11%)	1 (3%)
Hindered	2 (6%)	2 (6%)
Not applicable	1 (3%)	
Hostility toward giftedness reported	8 (22%)	7 (19%)
Olympians accused of elitism	4 (11%)	3 (8%)

100% of the Olympians believed their training experiences could be developed into a stimulating program for high-ability math students.

Table 4.7
Attitude Changes of the Olympians after Participating in Math Olympiad program

		Olympians	Parents
Learning	Positive changes	14 (39%)	18 (50%)
	No change	16 (44%)	14 (39%)
	Negative changes	6 (17%)	4 (11%)
Math	Positive changes	26 (72%)	25 (69%)
	No change	8 (22%)	10 (28%)
	Negative changes	2 (6%)	1 (3%)
Science	Positive changes	22 (61%)	18 (50%)
	No change	13 (36%)	16 (44%)
	Negative changes	1 (3%)	2 (6%)
College	Positive changes	11 (30%)	17 (47%)
	No change	24 (67%)	18 (50%)
	Negative changes	1 (3%)	0

Participation in program had negative consequences for 31% of the Olympians and 31% reported "burn-out."

One hundred percent of the Olympians believed that their training experiences could be developed into a stimulating program for high-ability math students. Twenty-two percent of the Olympians reported experiencing hostility toward their giftedness; and 11% of them were accused of elitism.

The Olympiad program provided rewarding experiences for the Olympians. The Olympiad program is not only a competitive program, it provides a variety of learning opportunities, including independent study, creative problem-solving, peer discussion, and challenge. It helped Olympians become aware of educational opportunities, positively change others' attitudes toward them, and helped them accept their own talents. There were negative side effects for few Olympians, and some experienced hostility or accusations of elitism. But, in general, the Olympiad experiences were positive for the Olympians, especially in learning attitudes toward math (72%) and science (61%).

College Life

The Olympians were admitted to the elite universities without great difficulty (see Table 4.8). Actually, many of them (74%) were accepted by universities through a special award program provided by the Ministry of Education. Through this program, those who are APMO or IMO winners are eligible to enter a special field of their interest and/or talent in the university without taking the joint entrance examination.

Unfortunately, the Olympians reported that almost none of the universities provided special programs for them, nor any individualized educational opportunities or mentorships. This is a pity and has obviously frustrated the Olympians. However, many Olympians also reported that they soon became accustomed to the new environment by finding their own interests and/or doing their own studies. They found that previous Olympiad experiences were very useful in helping them to think for themselves.

Table 4.8
Taiwan Math Olympians in College

		Olympians	Parents
Transition to college	M	3.6	3.4
(Scale: 1 to 10, very easy			
to very difficult)	SD	1.7	2.3
College provides special program for Olympian			
Provisions made		1 (3%)	2 (6%)
No provisions made		35 (97%)	34 (94%)
College provides individualized opportunities for Olympian			
Opportunities		0	2 (6%)
No opportunities		36 (100%)	34 (94%)
Undergraduate mentor			
Mentor provided		0	1 (3%)
No mentor provided		36 (100%)	34 (97)

Computer Literacy

The computer literacy of the Olympians varied according to their personal interests and the availability of computers. They spent an average of 7.46 hours per week on microcomputers (28 Olympians responding) or seven hours per week on main frame computers (only 8 responding). Most of them (75%) used PC/MS software for playing games (64%) or for word processing (56%). The average number of computer languages known by the Olympians was 1.8; the most common ones were Fortran and Basic. Two Olympians were almost, at the "expert level," and both reported using the Internet for years. However, most of the Olympians reported that their computer literacy was very junior (average of 2.57 in a 10-point scale) (Table 4.9). The learning styles of a few prevented their access to the computer. For example, one of the Olympians commented, "I'd rather spend my time in thinking rather than dealing with the machine, unless I really need it."

Academic Productivity

The math Olympians in Taiwan were still school/university students at the time the study was underway. According to their reports they did not have high levels of academic productivity. To date, only one article has been published and only three research papers have been presented. It is obvious that they are now "knowledge consumers" rather than "producers of knowledge." It is hoped that in the near future they will become very productive. On the other hand, this low level of productivity may be the result of less encouragement by the academic community in Taiwan.

Self-concept and Attributions

Concerning the Olympians' self-concepts and attributions, Table 4.10 indicates that the Olympians scored highly in terms of their math self-concepts (3.9), their science self-concepts

Table 4.9
Taiwan Math Olympians Computer Literacy

Access to computer			
Hours per week on microcomputer		M	7.46
(28 Olympians responding)		SD	5.83
Hours per week on main frame computer		M	7.00
(8 Olympians responding)		SD	9.78
Software used:			
PC/MS	27 (75%)		
Macintosh	6 (17%)		
OS2	0		
UNIX	6 (17%)		
Software program used	Microcomputer	Main frame computer	
Word processing	20 (56%)	0	
Math/statistic	15 (42%)	3 (8%)	
Spread sheet	9 (25%)	0	
Internet	2 (6%)	7 (19%)	
Database	3 (8%)	2 (6%)	
Games	23 (64%)	0	
Graphics	6 (17%)	1 (3%)	
Desktop publishing	11 (31%)	1 (3%)	
Number of computer languages known by Olympians		M	1.80
(26 Olympians responding)		SD	0.98
Computer literacy (10-point scale)		M	2.57
		SD	0.96

Table 4.10
Taiwan Math Olympians' Self-concept and Attributions

	M	SD
Math self-concept	3.90	0.44
Science self-concept	3.90	0.48
General self-concept	3.76	0.58
Effort attribution	3.43	0.49
Ability attribution	3.23	0.37

Based on a five-point scale.

(3.9), and their general self-concepts (3.76). The Olympians were not only confident in their math and science abilities, but their level of self-esteem was also high. On the other hand, the Olympians seemed to attribute their achievement to both effort and ability, the former being viewed somewhat more importantly than the latter.

Qualitative Data

There are abundant data collected from the in-depth interviews. There were great similarities as well as great differences among the Olympians. In short, the similarities were as follows.

Most of them were first-born children. Most came from higher SES families. Most reported that good teachers were critical persons in the development of their math talent. Most can concentrate easily in their studying. Most like to spend time in math thinking. Most like to think rather than to memorize. Most were curious about many things. Most were involved in many extracurricular activities. Most were largely independent in learning and were good time managers. Most were self-confident. Finally, their primary short-term career goal was to earn a graduate degree.

The differences among the Olympians that emerged from the interview data were the following. Some were very social and popular, others were very quiet and reserved. They were quite different in their science, art, politics, religion, and social sciences achievements and interests. They differed in their skill in writing Mandarin characters: some were very clean, others were very hasty. Some were involved in sports, others were strangers to sports. Some enjoyed sleeping and spent a lot of time in their beds, while others slept very little. Some liked to raise questions, others just listened in class. Some spent a lot of time with the computer, while others kept their distance from the computer. Some were strong and healthy, others were weak. Some were top students in many subjects in their classes, while others were only good in math or a few subjects. Finally, some were good in oral expression, others were not.

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Biography

Wu-Tien Wu received his Ph.D. from the University of Kentucky. He served as the Director of the Special Education Center at National Taiwan Normal University. He was awarded the Distinguished Educator of the year in 1985 and received a Distinguished Research Award from the National Science Council. He served as the President of both the Special Education Association and the Chinese Association for Psychological Testing. He is currently the President of the World Council for Gifted and Talented Children (1993–1997). He is the chief editor for the *Special Education Quarterly*, the *Bulletin of Special Education* and the *Gifted Education Quarterly*; he also serves on the Editorial Boards of the *Gifted and Talented International* and the *Gifted Educational International*. He has published 16 books and over 200 research papers and articles.

CHAPTER 5

NURTURING FACTORS THAT PROMOTE MATHEMATICS ACHIEVEMENT IN MAINLAND CHINA

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Abstract

Thirty-five Olympians (33 males and 2 females) and their parents participated in this study. The instruments consisted of Olympians'/Parents' Questionnaires, Self-confidence and attitude attribute Scales, and the Inventory of Parental Influence. The main results were as follows. Most of the Olympians came from intellectual families (both parents occupied high-status positions and had high levels of education). Most of the families had one or two children (25.7% were the only child in the family). Most Olympians studied in key middle schools and received instruction from teachers with excellent math backgrounds; more than half were enrolled in gifted classes in high schools. Most of the Olympians graduated from senior high school at the age of 17 or 18 and all had the highest grades ("excellent") in mathematics and most had "excellent/good" report card grades in all school subjects; however, they had few chances to learn to use computers. Most of the Olympians credit the Math Olympiad program with promoting the development of their math potential and producing positive changes in learning attitudes as well.

Introduction

The International Math Olympiad (IMO) has a long worldwide history. In Mainland China, however, participation began in 1985 for middle school students (Zhou & Lu, 1995). In ten years the Chinese mathematics delegations achieved considerable success in the IMO competitions. To date they have won 39 gold medals, 17 silver medals, and 4 bronze medals. Five times they achieved championship team scores (three times the teams placed second). The development of adolescent mathematics talent in Mainland China has attracted wide interest and attention.

This research study is part of a series of cross-cultural investigations of Math Olympiad contestants in the United States, Taiwan China, Mainland China, and Japan. As a result of this

project, it has been possible to probe into the development of adolescent mathematics talent. These studies have also been useful in learning how mathematical personnel in the different countries discover and foster the development of math talent.

Methods and Procedures

The sample consisted of 35 Mainland Chinese Math Olympians, including IMOs and Chinese Math Olympians (CMOs). The thirty-three males (94.3%) and two females (5.7%) came from seven large administrative areas and 16 cities in Mainland China, ranging from Heilongjiang in the north to Guangdong in the south, Xinjiang in the west, and Jiang Zhe in the east. While there were 35 families (total 70 parents), only 22 families and 41 parents returned the packet of instruments.

Four instruments were used in this study: Olympians' Questionnaire, Self-confidence and attitude attribute Scales, Parents' Questionnaire, and Inventory of Parental Influence scales (see Chapter 2). The Math Olympians were gathered in small groups and given the sets of instruments together with an explanation of what was required. The parents were mailed questionnaires with the expectation that they would return them upon completion. The data from the four instruments were recorded onto scantron pages and machine scored. All data were analyzed under standardized conditions.

Results

The results are organized into four sections. They are family background, school, math Olympiad program, and influencing factors.

The Family Background

The Olympians came mostly from intellectual families. The occupational status and educational attainment of the parents can be seen in Tables 5.1 and 5.2.

Most of the families (80%) had only one or two children. The birth order of the Olympians in the family was as follows: first child (including only child), 42.8%; second in the family, 42.8%; the rest (third or fourth), 14.3%. The average size of the families was 1.42 children.

During the early development of the Olympians, most of the families had many books in their homes (see Table 5.3). Furthermore, the majority of parents discovered their child's extraordinary math talent when their child was in primary or junior middle school (see Table 5.4).

Table 5.1
Occupation of Parents of Olympians (%)

Parents	Intellectual	Worker	Farmer	Home labor
Father	85.7	8.6	5.7	0
Mother	68.6	20.0	8.6	2.8

Table 5.2
Educational Attainment of Parents of Olympians (%)

Parents	College/above	Middle school graduate	Primary school/ under
Father	68.6	17.1	14.3
Mother	48.6	37.1	14.3

Table 5.3
Books in the Olympians' Families (%)

Books	Olympians	Parents
1. Very few books (0–9)	6.0	6.0
2. A few books (10–25)	3.0	0
3. One bookcase (25–99)	17.0	23.0
4. Two bookcases (100–249)	5.7	18.0
5. Three or more bookcases	68.6	53
M	4.29	4.11
SD	1.20	1.16

Table 5.4
Age when Parent Discovered Child was Gifted (%)

Different stages (age)	Percentage of children
Preschool (ages 1–6)	18
Elementary (ages 7–11)	35
Jr. High (ages 12–15)	41
Sr. High (ages 16–18)	6

Eighty-nine percent of the Olympians could speak one foreign language, but no one else in their families spoke any foreign languages. More than half of the families (51%) spoke standard Chinese (Mandarin); 49% spoke another dialect. Most of the Olympians (97%) spoke standard Chinese (Mandarin).

Only nine of the Olympians could play a musical instrument (25.7%) and most of the members of their families did not play any instrument (60%). However, in 35% of the families, one member played an instrument.

School

The Olympians mostly studied in key primary and middle schools (some of them were famous schools in the country). These schools paid careful attention to school reforms and raised teaching standards. The teachers involved in the Math Olympiad program had rich experiences to share with the students and also had more extensive math backgrounds. These Olympians did not have

any access to gifted classes when they studied in primary school and only 30% were provided gifted classes in the junior middle school. However, 65% of the Olympians were enrolled in gifted classes in the senior middle schools.

Most of the Olympians scored "excellent" (highest grade) in their studies before graduation from middle school. One hundred percent scored "excellent" in mathematics, and 90% scored "excellent" in physics. Very few subjects scored "average," and there were no "poor" scores (see Table 5.5). Most of the Olympians (85.7%) graduated from their senior middle schools at the age of 17 or 18 (see Table 5.6).

The Olympians had little chance to learn to use computers. None of them ever used a main frame computer, but some used microcomputers (see Table 5.7). On a five-point scale they estimated their level of computer literacy to be between mid-level and a rather low level ($M = 2.57$, SD = .96).

Most of the Olympians graduated from middle school. Sixteen of them are studying at Beijing University; 14 are enrolled in Qinghua University (totaling 30 or 85.7%). Five of the Olympians have graduated from universities and are studying for their MA or Ph.D. degrees (14.3%). Those who graduated from middle school experienced no difficulties in being admitted to different universities. The universities, however, did not provide special programs or individualized opportunities for them.

Math Olympiad Program

The Olympians and their parents evaluated the Math Olympiad program. The overall evaluations were quite positive. Eighty-nine percent of the Olympians (and 90% of their parents) believed they would not have achieved as much without participating in the program. Eleven percent (and 10% of the parents) considered it difficult to estimate program impact or felt that there was no impact.

Eighty-three percent of the Olympians (and 85% of their parents) credit the Math Olympiad program with increasing their educational opportunities. Six percent of the Olympians (and 15% of their parents) said there was no increase in educational opportunities.

Slightly more than 91% of the Olympians (and 90% of the parents) stated that the Math Olympiad program helped them understand and appreciate their own ability; about six percent considered it neither helped nor hindered and 2.9% considered it a hindrance. Ten percent of the parents did not give any answer.

The results indicate that 77% of the Olympians (and 80% of the parents) considered that the

Table 5.5
Learning Achievements of the Olympians Before Graduation in Senior Middle School (%)

Grades	Chinese	Math	Physics	Chemistry	Biology	Foreign language	Total score
Excellent	35	100	90	55	50	35	60.8
Good	55	0	10	40	40	65	35.0
Average	10	0	0	5	10	0	4.2
Poor	0	0	0	0	0	0	0

Excellent = 90–100, good = 75–89, average = 60–74, poor = 59 or under.

Table 5.6
Age at High School Graduation

Age	15	16	17	18	19
Number	1	0	13	15	4
%	3.0	0	39.4	45.4	12.1

Table 5.7
Microcomputer Used (%)

Word processing	9.0
Math/statistics	6.0
Spread sheet	0
Internet	0
Database	6.0
Games	11.0
Graphics	0
Desktop publishing	0

Math Olympiad program had positively changed the attitude of others. The change in attitudes of the Olympians after participating in the Math Olympiad program can be seen in Table 5.8. Sixty percent of the Olympians report no negative effects from participation, whereas 40% consider there were some negative effects, such as strain and pressure. Twenty-three percent of the Olympians felt the competition exhausted them.

Table 5.8
Participation in Program Changed Olympians' Attitudes (%)

Item	Olympians	Parents
Learning		
Positive changes	74	77.7
No change	14	16.7
Negative changes	11	5.6
Math		
Positive changes	80	89
No change	8.6	5.5
Negative changes	11.4	5.5
Science		
Positive changes	77	72
No change	11	17
Negative changes	9	5.5
Missing	3	5.5
College		
Positive changes	57	66.6
No change	20	22.2
Negative changes	17	0
Missing	6	11.1

Influencing Factors

Eighty-six percent of the Olympians consider the most influential person responsible for the development of their math talent was their teacher (50%), while 36.1% consider their parents to be the most influential (see Table 5.9). Table 5.10 shows the results of the parents' perceptions of their influence. Psychological support and the press for intellectual development are more important than the other parental factors.

Table 5.9
The Most Influential Person to Math Talent of the Olympians (%)

Parent	Teacher	Himself	None
36.1	50.0	5.6	8.3

Table 5.10
Home Factors Influencing Olympian's Talent

	Mothers' perceptions		Father's perceptions	
Factor	M	SD	M	SD
Pressure	2.44	0.49	2.50	0.49
Psychologial support	3.80	0.48	3.67	0.57
Parental help	3.16	0.90	3.06	0.92
Press for Intell. Dev.	3.74	1.13	3.85	1.10
Monitoring	3.44	1.10	3.42	1.13

Table 5.11
Olympians' Self-concepts and Attributions

Factor	M	SD
Math self-concept	3.70	0.49
Science self-concept	3.25	0.40
General self-concept	3.78	0.60
Effort attribution	3.55	0.40
Ability attribution	2.80	0.41

According to the results of the Self-confidence and attitude attribute Scales, general self-concept, math self-concept, and science self-concept were all high. Effort attributions were higher than ability attributions, which indicate that the Olympians consider personal effort to be more important than ability (see Table 5.11).

Discussion

The results of the study suggest three main conclusions. These are discussed in this closing section.

Development of Math Talent

According to responses given by the Olympians and their parents, the Olympians became interested in mathematics very early in their lives (see Table 5.12). More than three-quarters of

Table 5.12
Age When the Olympians Began to be Interested in Mathematics (%)

Age stage	Preschool	Primary School	Junior Middle School	Senior Middle School
Olympians	20.6	55.9	20.6	2.9
Parents	45.5	54.5	0	0

Olympians: 34, parents: 22.

the Olympians became interested in math during their primary school years or before they started school. Referring back to Table 5.4, one can see that most parents discovered the Olympians' math talent during the primary school and junior high school years (76%). Perhaps the main reason for their delayed recognition is due to the time of their birth — 80% were born before 1975. The special education for intellectually gifted/math talented children began only after 1978 (Zha, 1993). At that time parents did not give sufficient attention to the early education of their children. According to this study, only 40.9% of the parents gave the Olympians rudimentary education in mathematics when they were young.

The main manifestations of math talent of the Olympians were that they liked mathematics and had self-confidence in their math abilities, achieved "excellent" grades in mathematics, and were the highest in achievement in mathematics contests. More than 50% received prizes and medals many times in primary and middle school math contests, and 100% won medals in IMO or CMO.

Factors Accelerating the Development of Math Talent

Based on the results of this study, the development of math talent involves the combination of many factors. The main factors accelerating the development of the Olympians' math talent are the positive home atmosphere and the parents' influence on early education, a solid foundation in education and the guidance of good teachers, encouragement and tempering of the contest activity, and the psychological stability and effort of the Olympians. The appropriate combination of these four aspects accelerated the development of the Olympians' mathematical talent.

Different facets have different influences on the Olympians. These facets are essentially common factors that promote the development of all kinds of gifted/talented children (Zha, 1994).

Parents stimulate the interest of the Olympians in mathematics through imperceptible influences such as the father's positive encouragement, parents' expectations (especially hoping that the child could enter key universities), concern about the child's studying, establishing a good family atmosphere for learning and studying, having many books at home that can arouse the child's interest in mathematics, encouragement to study hard, concern about the achievement of the child, and insistence that the child finish his homework every day.

Most Olympians came from key middle schools that provided them with a solid educational foundation. Seventy-five percent had chances to enter gifted classes in high school or other after-school groups that had special education; 77.8% of them said they had been instructed by excellent teachers; and 75% reported benefitting from the teacher in charge of the gifted class.

Almost 90% of the Olympians attributed their present mathematics achievement to the Math Olympiad program. They considered the participation in mathematical group training to be helpful and believed that the Math Olympiad program stimulated their interest in mathematics and accelerated their positive change in attitude toward math and science.

Finally, the Olympians have developed a commitment toward learning mathematics. For example, they are interested in mathematics, like to solve mathematical problems, and have confidence in learning. Very few of them missed any class unless for special reasons; more than 80% believe that good achievement depends upon diligence and effort.

Evaluation of the Math Olympiad Program

Middle school mathematics contests have been launched rather early in some countries. In 1959 the first International Math Olympiad was held in Romania, and from then on every year this kind of competition has been held (Pu, 1995). Yet Mainland Chinese Olympians participated for the first time in 1985, over a quarter century later. Although these participants do not have a long history of participation, their achievements are outstanding. Chinese adolescents have great potential in mathematics and the overall standard of high achievement in mathematics in China is swiftly rising.

In the last ten years in Mainland China a "pyramid Math Olympiad selection system" has been established. Different stages of coaching are delineated. A "three combination" team of coaches consisting of excellent mathematics teachers and research workers play an important role in fostering the Olympians' development. All the Olympians that have been studied were instructed by senior coaches and attended lectures and training classes given by more than thirty senior coaches (Tao, Lui, & Zha, 1995).

Every year 10 million middle school students participate in the mathematics contests. Through the selection process, the student's interest is encouraged; competitiveness and initiative strengthened; capacity to think independently and accurately is encouraged; flexibility and alertness are fostered; ability to solve problems creatively promoted; and persistent character is tempered. The Math Olympiads are helpful in discovering talented math personnel and have positive effects on educational reform, which raises the level of performance of teachers as well. These positive aspects of the Math Olympiad program are consistent with the reactions of the Olympians and their family members.

As to whether there are any negative effects of participating in the Math Olympiad, 40% of the Olympians feel there are some. They point to two aspects. First, there is certain degree of focusing on one subject. Some said because too much time was spent on mathematics, the learning of Chinese and foreign languages was hindered. Second, some experienced psychological pressure. There was too much stress; they were afraid of failure. Some expressed solitary feelings. These problems have already received attention, and measures for improvement have been adopted.

Another question was uncovered in this study — after the Olympians obtain prizes, how

should their talent be further developed? The Olympians in this study could not get special guidance from their teachers after entering their university. This is a problem that needs to be addressed in the future.

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Biographies

Zha Zixiu graduated from Jinling University (Najing, China). Her research interests include development psychology and the study of gifted children. She is the Director of the Center for Gifted Children at the Institute of Psychology, Chinese Academy of Sciences and the Leader of the Supernormal Children's Cooperative Research Group of China. Her contribution to research concerning Chinese gifted children has won her numerous awards. She is the author or co-author of 9 books and more than 60 research papers and articles.

Liu Pengzhi graduated from the Faculty of Mathematics, Beijing Institute of Education. She is a Vice-Principal of the high school attached to the People's University of China and the Principal of Hua Luogeng School. She is a senior math teacher and a senior coach for the National Math Olympiad. She has authored numerous school-level text books and reference books in mathematics.

Tao Xiaoyong graduated from the Faculty of Mathematics, Beijing Capital Normal University. He is an Associate Professor in the Mathematical Faculty of the Beijing Institute of Education. He is also the Secretary General of the Beijing Mathematical Olympiad Development Center, Deputy Department Head of the Secondary Education Committee in the Beijing Mathematical Society, and a senior coach for the National Math Olympiad training squad. He is the author of several Chinese junior college-level math texts and competition math reference books.

CHAPTER 6

ACHIEVING MATHEMATICAL EXCELLENCE IN JAPAN: RESULTS AND IMPLICATIONS

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Abstract

This chapter describes how the Math Olympiad program operates in Japan. Mathematics achievement in Japan has been acknowledged around the world. Japan's success in the International Mathematics Olympiad (IMO) is documented and the reasons behind this success are examined. Finally, problems dealing with the mathematics curriculum are presented.

Introduction

In 1873, through Western influences, Japan established a modern education system. Since then, Japanese (as the national language) and mathematics have been important core subjects taught from elementary to senior high school. With the introduction of democracy after the end of World War II, the Japanese education system went through a complete reform. Certain school subjects were modified, but the way in which Japanese and mathematics are taught has remained unchanged over the years.

In the 1960s Japan, like the rest of the world, began modernizing the content of its education system. However, unlike other nations, Japan made no changes in mathematics education except to improve on it. In Japan mathematics is an important skill that facilitates the understanding and development of the nation's culture. To the Japanese it is the very foundation and basis of cultural refinement.

The Establishment of the Mathematical Olympiad Foundation of Japan

In order to further develop Japanese culture and economy and to enhance science and technology, it is necessary to take mathematical education one step further toward its full potential. With that purpose in mind, the Mathematical Olympiad Foundation of Japan was established in March 1991. After establishing the Japanese Mathematical Olympiad (JMO), the foundation went on to participate in the International Mathematical Olympiad (IMO).

The foundation selects representatives for the IMO and undertakes all things involved with the IMO. The foundation also conducts research in high school mathematics education based on the results obtained from the JMO and the IMO, with the purpose of improving the current math curriculum. In short, the foundation's objectives are to:

1. select and prepare Japan's representatives in the IMO and host the JMO;
2. conduct research on mathematics teaching methods and mathematics education in senior high schools;
3. hold courses/lectures and publish articles and findings related to the JMO and IMO; and,
4. undertake any other things necessary to attain those objectives.

The Japan Mathematical Olympiad

As mentioned previously, the Mathematical Olympiad Foundation of Japan holds the JMO annually. The basic outline and rules of the event are outlined in this section.

The winner of the JMO is awarded the Kawai Trophy (Mr Kawai is the founder of the JMO). Gold, silver, and bronze medals are awarded to participants who achieve the top results. Of the top ranking participants, six are chosen to represent Japan in the IMO.

Participants of the JMO must be under 20 years of age and, as a general rule, currently attending elementary to senior high schools. The examination questions are based on what is taught in the tenth grade mathematics curriculum. The questions involve algebra, geometry (equations, planar geometry, etc.), analytical problems (progression, inequality, etc.), permutation problems; at times, there are some unfamiliar problems. The majority of participants for these exams are enrolled in the 10th and 11th grades (see Tables 6.1 and 6.2), and 60% of the prizes are won by 11th-grade students (see Table 6.3).

The regional JMO is held at seven sites nationwide. The participants are required to take a three-hour exam composed of twelve questions. The top 100 participants are awarded a pass, and a third of those who pass, by region, are awarded a prize.

Participants in the National JMO are required to take a four-hour exam comprised of five

Table 6.1
Grade Levels of Participants (%)

	Years				
Grades	1992	1993	1994	1995	Average
12	1	1	1	1	1
11	44	48	46	47	46
10	40	35	37	34	33
9	6	8	10	9	8
8	3	4	4	4	4
7	1	2	2	2	2
6		1		1	1
5	1	1			1
Other	5	3	1	3	3
Total participants	1,385	1,534	1,243	1,369	

Table 6.2
Grade Levels of Passing Participants (%)

	Years				
Grades	1992	1993	1994	1995	Average
12	0	0	0	0	0
11	58	48	53	66	56
10	27	35	37	26	31
9	11	16	7	7	10
8	2			2	1
7			2		1

494 participants passed the exam.

Table 6.3
Grade Levels of Prize Winning Participants (%)

	Years				
Grades	1992	1993	1994	1995	Average
12	10	0	0	0	2
11	74	59	37	70	60
10	16	18	42	20	24
9		23	16	10	12
8			5		1

75 participants won prizes.

questions. The top 20 finalists are awarded prizes including medals. The first place winner is awarded the Kawai Trophy. During the first week of March, the top twenty participants take another exam that decides the six representatives for Japan in the IMO.

The percent of JMO participants that are awarded a passing grade each year are illustrated in Table 6.4. Most of the participants in the Japanese Olympiad program are males. Similarly, the overwhelming majority of those receiving passing grades and winning prizes are also males (see Table 6.5).

Table 6.4
Difficulty of Exam (Percent)

	Years			
	1992	1993	1994	1995
Passing	9	6	10	13
Failing	91	94	90	87
N	1,385	1,534	1,243	1,231

Table 6.5
Gender of Participants

Average	Years 1992	1993	1994	1995
Percent males participating	92	91	94	90
Percentage females participating	8	9	6	10
Percentage males achieving passing scores	98	99	100	98
Percentage females achieving passing scores	2	1	0	2
Prize winners				
Percentage male	95	100	100	100
Percentage female	5	0	0	0

485 males passing, 9 females passing, 74 male prize winners, 1 female prize winner.

Japan's Participation in the IMO

Japan actually participated independently in the IMO in 1990, but with the establishment of the Mathematical Olympiad Foundation in 1991, the participation of Japan in the IMO has become the undertaking of the foundation. From the regional and national Olympiads, six finalists are chosen to represent Japan in the IMO each year. The following are the results of the Japanese finalists in the IMO:

*31st Annual IMO — Peking (1990)
Japan placed 20th and collected 2 silver medals and 1 bronze medal
*32nd Annual IMO — Sweden (1991)
Japan placed 12th and collected 3 silver medals and 3 bronze medals
*33rd Annual IMO — Moscow (1992)
Japan placed 8th and collected 1 gold, 3 silver and 1 bronze medal
*34th Annual IMO — Istanbul (1993)
Japan placed 20th and collected 2 silver medals and 3 bronze medals
*35th Annual IMO — Hong Kong (1994)
Japan placed 10th and collected 1 gold, 2 silver and 3 bronze medals
*36th Annual IMO — Canada (1995)
Japan placed 9th

Japan has only participated in the IMO six times, but the results are showing improvement. Such results have demonstrated the high standard of mathematics education in Japan on an international level.

Reasons behind Japan's Success in the IMO

Japan's excellence in mathematics education has been demonstrated to the world via the IMO. Several reasons can be given for its success.

First, since the modernization of the Japanese education system, mathematics has been an important element in schooling. There have been many educational reforms since the Meiji Period, but mathematics has remained a core subject for all students from elementary through senior high school.

Second, Japan's performance in the IMO can also be attributed to the high standards of the mathematical curriculum. Although the contents of mathematics textbooks have been set by the Ministry of Education, Culture, Sports and Science's (hereafter Monbusho) *Course of Study* (1991) guidelines, its high standards are comparable to those of other nations.

After World War II, various educational reforms took place based on ideas from the experimentalist school of education. Insofar as mathematics was concerned, the traditional ideas held fast, and the high standard of mathematical education has been maintained to the present day. In fact, the type of questions that appear in the JMO are all based on the national 10th-grade curriculum. This means that *all* participants should be familiar with the content of the examination.

Third, Japan's teacher education is also of a high caliber. Elementary to senior high school teachers have all graduated from education departments of national universities or teachers' colleges; most teachers have completed masters courses. In the science and education faculties, training students to teach mathematics is a part of the curriculum. The general guideline for mathematics teacher training in national universities is set by Monbusho, and it is internationally recognized for its high standards.

Fourth, mathematics is a core subject for college/university entrants. Although there are some exceptions, most faculties of national universities feature mathematics in their entrance examinations. Even in private universities, mathematics is an important subject for students who wish to enter the scientific, engineering, medical, or agricultural fields. Mathematics is also a required subject for entering junior and senior high school.

Fifth, special mathematical education for academically gifted students does not exist in Japan. The excellent results in the JMO and IMO were not achieved by mathematical geniuses. Since the introduction of democracy in Japan in 1945, Monbusho (1992) has opposed the development of special education for gifted students, unlike other countries. Monbusho is beginning to recognize the need for special education, but plans for reform are in the early stages and will take years until they are put into practice.

Problems Concerning Mathematical Education in Japan

The current Japanese education arose from the democratic principle of equal opportunity for all people, a "renaissance-like" concept introduced in Japan after the World War II. However, the right to education for all people saw a dramatic increase in students enrolling into non-compulsory senior high school. Over 80% of junior high school students continued their education into senior high school in the 1970s. Today, the figure is about 98%. Furthermore, 50% of senior high school students enroll in universities or colleges. In other words, the Japanese education system is going through a rapid expansion. Today, junior and senior high school education in Japan is sought by virtually everyone.

In terms of improving the standard of education in Japan, such a phenomenon should be regarded as favorable since it can be attributed to Japan's economic success. However, the current state of the education system has unexpectedly given rise to a few problems, one being the question of educational quality in Japan. Here are two examples of this problem.

First, there is the problem of "dropouts," those students who simply cannot keep up with the current curriculum. Approximately 40% of senior high school students cannot understand what is being taught, especially in the areas of mathematics, physics, and chemistry.

In response to this discovery, Monbusho has proposed to diversify the mathematical curriculum so that students will be able to concentrate on areas of mathematics in which they are capable. Unfortunately, it will be difficult and unlikely for such a proposal to be carried out immediately in this current situation.

Second, there is the problem of students who excel in the areas of mathematics, physics, and chemistry. Currently, under the system of standardized and conformist education, students are not able to fully develop their potential. Consequently, there has been an outcry for a fundamental reform concerning educational quality.

Exceptional Students of the Japanese Education System

In order to reform an education system based on perfunctory equality to that of one based on essential equality, Monbusho has published an official document entitled, *Reforming the Education System for the Future*. In the document Monbusho recognizes the need to accept that students have different abilities in certain subject areas. Monbusho recognized that gifted students' abilities should be encouraged to grow; but at the same time Monbusho does not want to create a system where certain students are to be labeled as "academic elites" or put into a higher grade.

In 1994 Monbusho published the final report from the meeting held by the Special Education Research Group entitled, *Developing and Enriching Education for Exceptional Students*. The main points from the report are as follows:

1. gifted students should be able to expand their abilities in the area of mathematics and physics;
2. gifted students and those who wish to expand their individuality and creativity should be recognized and special educational provisions should be developed to accommodate them; and
3. exceptional educational opportunities should be developed (e.g., gifted students should be able to attend classes at a university, receive individual guidance by university professors, and participate in university lectures).

Gifted students should also be encouraged to listen to radio broadcasts by university faculty and to participate in various advanced seminars. In 1994 Monbusho took its first step towards achieving the above goals.

The Japanese education system has entered the age where quality of education has become the top priority. From the perspective of gifted education, Japan may be regarded internationally as a developing nation. Today, Monbusho is directly tackling educational problems that require an effective solution.

However, considering the vast history and traditions of the Japanese education system, Japan's high standard of teachers and their teaching methods, and the intense concern directed

towards education, it will not be long until educational excellence is apparent not only in mathematics but also in all other fields of study. Phenomenal developments in Japan's education system can be expected and gifted education in Japan will one day be regarded very highly by the rest of the world.

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Biography

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CHAPTER 7

THE OLYMPIAD MOVEMENT IN RUSSIA

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Abstract

This chapter traces the academic Olympiad movement in Russia from its beginning in 1934 to the present. It describes the many changes that have occurred over the years and the proliferation of Olympiad competitions that have spread over Russia. Finally, the effects of these competitions on individual Olympians are illustrated.

Development of the Olympiad Movement in Russia

Atypical solutions of difficult problems always attract people. One can remember the Trojan horse and the mathematical duels in the middle ages (for example, the duel of Antonio Maria Fior against Niccolo Tartaglia). In Russia, the *Journal of Elementary Mathematics*, published in Kiev (Russian Empire) in 1864, contained such problems. This journal was written for teachers and their pupils and contained a section of math problems. The solutions prepared by readers were published afterwards. By the end of the 19th century, the interest in the solution of challenging problems had been incorporated into the first mathematical competitions for the gymnasium graduates in Austria-Hungary and had also reached the United States.

The Russian Math Olympiad began in 1934 when a group of famous mathematicians (B. N. Delone, O. K. Zhitomirski, B. A. Tartakovski, D. K. Faddeev, G. M. Fikhtengolts) initiated the first Leningrad City Math Olympiad. The participants had to go through three sets of exams (tours): the first was a take-home examination; the second was a written examination; and the third examination was verbal.

From time to time the rules for the Olympiad have changed. Younger participants gradually became involved; the lower age limit today is 12 years. New rules for carrying out the Olympiad have been tried. For some years all contenders were given exactly the same problems, but at other times the participants were given different problems. The number of exams kept changing as well.

The Moscow and Kiev City Olympiad have been held since 1935. The Moscow Olympiad was started by mathematicians (L. G. Shnirelman, L. A. Liusternik, P. S. Aleksandrov, A. N. Kolmogorov, V. F. Kagan, S. L. Sobolev, S. Y. Yanovskaya) who served as members

of an organization committee. The Olympiad consisted of two exams. The number of pupils tested for the first exam was 300 pupils and for the second, 120. The top three scorers (I. Zverev, I. Korobov, A. Mishkis) on the second exam were awarded first prizes.

At the suggestion of A. N. Kolmogorov, three sets of problems were presented to the participants in the second exam: calculation and algorithms, geometry, and combination-logic. However, the rules have changed again and, currently, contenders solve only one set of problems.

The first five Olympiad were held without dividing contenders among age groups. However, since 1952 participants in the same age group compete with each other.

Muscovite mathematicians have worked closely with pupils taking these exams. This is clear when listing the chairmen of Moscow Olympiad (Table 7.1).

The initiator of Olympiad in Kiev was Professor I. F. Kravchuk. Afterwards, academician I. I. Bogolyubov led the organizational work. Other cities and republics of the former USSR started conducting their own city or regional Olympiad in the 1940s and 1950s. Finally, the idea of conducting an All-Soviet-Union Olympiad was considered. In 1960 pupils from different parts of the USSR were invited to the Moscow Olympiad. Simultaneously, the second exam of the Moscow Olympiad became the first All-Russian Math Olympiad. This exam was administered in 1961. The chairman of Moscow State University (academician I. G. Petrovski), the Deputy Minister of Education for the Russian Federation (Professor A. I. Markushevitch), and the head of the math study group at the Moscow State University (MSU) supported the project.

At the beginning, the All-Russian Olympiad were held in Moscow. Later, the Olympiad were conducted in different Russian cities. In 1967, after the Ministry of Education of the Soviet Union assumed responsibility for the Olympiad, they were renamed the All-Soviet-Union Olympiad. Later, central organizational committees were formed for mathematics, physics, and chemistry. For a long time academician A. N. Kolmogorov directed the central organizational mathematics committee.

The Olympiad greatly influenced the academic Olympiad movement in the U.S.S.R. and had an impact on pupils' interest in math. The success of the U.S.S.R. in space exploration caused an interest in physics as well. The discussion of the so-called problem of "physicists and lyrics" was very popular in Russia. As a result, the Olympiad movement expanded to include the following subjects: physics, chemistry, biology, geography, and linguistics.

Gradually, the number of participants taking the final All-Soviet-Union exam became too large to administer. Every region sent four finalists along with the prize winners of the previous competition. The number of team members, leaders, members of organizational committee, and professors eventually reached 800. To solve this problem, a decision was made to increase the number of exams and consequently reduce the number of participants. As a result, the "Republican" exam (fourth exam) has been held since 1975.

Russia itself was divided into four regions. The regional winners of the Republican exam, together with two teams from Moscow and Leningrad, gathered in Moscow for the All-Soviet-Union exam. All Republican Olympiad were held at the end of March during the spring break. The Russian Republican Olympiad competition was called All-Russian.

The Olympiad, apart from the All-Soviet-Union, were initiated in the 1960s. The Moscow Institute of Physics and Mathematics (MIPM) started its own Olympiad in 1962. These Olympiad were held by the students at the Institute in their home towns. The first set of these Olympiad was held in 58 cities. Later, other colleges and institutes conducted their own Olympiad.

The All-Siberian Math Olympiad appeared in 1962. This competition covered Siberia and the Far East and was organized by the Siberian Department of the Academy of Sciences of

Table 7.1
U.S.S.R. Olympiad and Chairpersons

Olympics number	Year	Chairman
1	1935	P. Aleksandrov
2	1936	N. Glagolev
3	1937	A. Kolmogorov
4	1938	A. Kurosh
5	1939	L. Liusternik
6	1940	L. Pontriagin
7	1941	A. Gelfond
8	1945	I. Gelfand
9	1946	S. Galperin
10	1947	I. Petrovski
11	1948	V. Nemitski
12	1949	A. Markushev
13	1950	M. Kreines
14	1951	B. Delone
15	1952	D. Men'shov
16	1953	P. Rashevski
17	1954	S. Bakhvalov
18	1955	G. Shilov
19	1956	E. Dinkin
20	1957	O. Oleynik
21	1958	V. Boltianski
22	1959	E. Landis
23	1960	I. Shafarevich
24	1961	V. Efremovich
25	1962	N. Efimov
26	1963	A. Kolmogorov
27	1964	I. Sharafevich
28	1965	N. Efimov
29	1966	A. Kronrod
30	1967	V. Nemitski
31	1968	I. Bakhvalov
32	1969	V. Efremovich
33	1970	V. Alekseev
34	1971	I. Shafarevich
35	1972	B. Demidovich
36	1973	A. Kirillov
37	1974	V. Arnold
38	1975	A. Kolmogorov
39	1976	A. Arkhangelski
40	1977	V. Uspenski
41	1978	Y. Manin
42	1979	V. Tikhomirov
43	1980	A. Mischchenko
44	1981	O. Lupanov
45	1982	O. Lupanov
46	1983	O. Lupanov
47	1984	O. Lupanov
48	1985	O. Lupanov
49	1986	O. Lupanov

the U.S.S.R.. The aim of the Olympiad was to attract the gifted youth to the colleges, MIPM, Novosibirsk University, and similar institutions.

Mathematics Study Groups

Along with the Olympiad movement, a system of training pupils for the Olympiad was developed. After the first Math Olympiad in 1935, lectures were conducted at the Institute of Mathematics in Moscow and school study groups were formed. The famous math study group at MSU started functioning at this time. The organizers of the project were well-known scientists (L. A. Liusternik, L. G. Shnirelman, and I. M. Gelfand).

The group operated in two ways — attending lectures and working in study groups. The lectures were delivered twice a month by the professors at MSU. Hundreds of pupils attended the lectures, which were complete and separate from each other because the audience always varied. Each lecture lasted 2 to 3 hours. Later, different lectures were delivered to different age groups (see Table 7.2).

The study groups were conducted by students at MSU. Shnirelman and Kolmogorov individually directed the work of two groups. Generally, groups of participants prepared and discussed reports. However, these activities were quite ineffective because the pupils did not prepare interesting and sound reports, review the related literature, nor answer all the questions posed by such reports. Shklyarski, á former student at MSU, managed to change the way the study groups operated. As a talented mathematician and teacher, he canceled the use of reports during his tenure as a group leader from 1938 to 1941. He, himself, delivered a brief speech and

Table 7.2
Lectures Delivered from 1930 to the 1950s

L. Shnirelman: *Multidimensional geometry*
L. Liusternik: *Convex figures*
A. Kolmogorov: *Main theorem of algebra*
S. Sobolev: *What is the mathematical physics?*
P. Aleksandrov: *Transfinite numbers*
V. Golubev: *How the plane flies?*
A. Hinchin: *Related fractions*
A. Markushevitch: *Difference equations*
A. Gelfond: *Simple numbers*
L. Liusternik: *Geodesic lines*
B. Deloney: *Geometric decisions of Diophantine's equations*
I. Gelfand: *Principle of Dirichlet*
A. Kolmogorov: *Number theory and its application in techniques*
Y. Dubnov: *Axioms of geometry*
L. Pontryagin: *What is topology?*
I. Shafarevich: *Decision of equations in radicals*
A. Kurosh: *What is algebra?*
N. Glagolev: *Construction with only a ruler*
A. Markushevich: *Squares and logarithms*
E. Dinkin: *Mechanisms and nervous nets*
A. Kronrod: *What is programming?*
V. Efremovich: *Non-Euclidean geometry*
N. Bary: *Number theory of infinity*
G. Shilov: *About derivative*
R. Dobrushin: *Mathematical methods of linguistics*
V. Boltianski: *Related fractions and music tunes*
I. Yaglom: *How to measure the information?*
O. Oleynik: *Theorem of Helly*
V. Uspenski: *Supplements of mechanics to mathematics*

then presented related problems to solve. Group members worked on the problems individually as well as collectively. They then discussed solutions instead of giving reports. Sometimes a difficult theorem was divided in several parts, and the group members had to prove the theorem themselves. This style of working with pupils proved to be successful.

The famous mathematician and teacher Khinchin (1963) wrote: "In most cases the problem solution requires only limited knowledge and skills . . . [the] math problem requires thinking that leads to a right solution. Therefore this process is an act of creativity. That is why math problems attract young, learning intellectuals. The person who has experienced happiness in achieving this mission will try everything possible to experience it again."

The students at MSU started serving as aides to Shklyarski. During the problem-solving process they answered questions and directed the pupils. Afterwards, they checked the work of the participants.

Shklyarski's method proved to be successful at the Fourth Olympiad in 1938. His group members won twelve prizes, including all four first prizes. As a result, all other study groups adopted Shklyarski's method. Shklyarski died in the guerrilla war against Germany in 1942. However, his name is known to every person interested in the Soviet Olympiad movement.

Many aspects of the study groups are impossible to highlight today. However, one can find interesting materials. The series, *Library of math study groups*, is still being published. The first issues of the series consists of three books of selected problems and theorems of elementary math.

Although Shklyarski did not participate in writing these books, he is noted as one of the authors. This is due to the fact that he greatly influenced the series with his activities. That is why the question, "where do I find the particular problem?" is answered this way: "see Shklyarski."

Schools of Physics and Mathematics (SPM)

Since capable teachers are needed, the organization of math study groups is possible only in large cities. Therefore, pupils from other regions often find themselves at a disadvantage. University entrance exams clearly show that pupils from large cities have better scores in the higher-order-skills areas of the exam. For this reason, in the 1960s the All-Soviet-Union Unattended Math School (AUMS) was established at MSU. (Today the school is called All-Russian Unattended Math School.)

The pupils from grades 9 to 11 who are interested in AUMS solve problems and send their solutions to AUMS. Problems were initially published in the regional youth papers. Today, however, the problems can be found in the magazine *Kvant*. Imaginary thinking rather than routine thinking is necessary to solve these problems. After pupils successfully complete the first level of problems, they receive a new set. A brochure is sent to the pupils containing the theory involved and dozens of problems. Pupils solve these problems and send them to a special committee. Solutions are checked, evaluated, and sent back to the pupils with advice and further directions. Pupils failing to complete the task are able to form special study groups in their schools under the supervision of a teacher. Upon completing the school year, one or two advanced pupils are trained individually.

Pupils can join AUMS at any grade. AUMS involves three years of study. The AUMS curriculum is defined by the School Scientific Council. Pupils in AUMS study math problems in-depth, which is different from the way problems are studied in ordinary schools.

Today AUMS has branches in St Petersburg and two dozen other cities. The Moscow Institute of Physics and Techniques (MIPT) and MSU own separate unattended schools of physics and mathematics (SPM). Pupils in these schools study math and physics extensively, having classes in these subjects for more hours than in ordinary schools. (Every school had the same curriculum in the Soviet Union. This is not the case today.) It is very difficult to be accepted in these schools because of the competition. Very often university professors teach in these schools. Their work is crucial for the success of these schools.

In 1963 the first SPMs with dormitories were opened in Moscow, Leningrad, Kiev, and Novosibirsk. Pupils from provincial towns and regions are able to study and live at the SPM. University professors and students teach in these schools. The experiment to add mathematical analysis to the school curriculum was first attempted in these schools. Today all schools have the course "Algebra and Basics of Analysis."

The SPM, with a dorm at MSU, admits 360 pupils each year (for details see Kolmogorov, Vavilov, & Tropin, 1981). The whole process requires several exams. Unfortunately, skills and abilities are not the only things measured in this exam. Children of factory workers and farmers are supposed to account for more than 50% of all the pupils. The schoolwork at SPMs is hard: 3 hours of lectures, class work with two professors, laboratories, special courses, practical work, and consultations make up 10 to 12 hours of math every week. Pupils can also attend voluntary study groups and conferences held by the scientific council of pupils. Pupils participate in school Olympiad as well.

As a result of their work in these schools, the majority of the graduates are accepted in the leading universities. Pupils of SPM successfully compete in Olympiad too. For example, from 1963 to 1980, SPM pupils won 14 first, 29 second, and 27 third prizes in the All-Soviet-Union Olympiad. Today one SPM is functioning at MSU and is called Kolmogorov Special Scientific Studying Center (SSSC).

Additional Overtime Work with Pupils

Teachers working overtime with able pupils is the usual practice in Russia. Unfortunately, insufficient funds are allocated for this type of activity by the State and the work is completely sustained by the enthusiasm of the teachers.

Since space is limited, descriptions of the overtime activities with able pupils are brief.

1. Ordinary schools: Voluntary group work in a particular subject, "week of math," is conducted in schools where pupils compete in problem-solving competitions. Interesting problems are published in the school newspaper. Serious math work cannot be done in ordinary schools, but the teacher can direct the pupils to such work.
2. SPMs: Four schools in Moscow, two schools in St Petersburg, The Lyceum in Vyatka, and others.
3. Special scientific studying centers: Special scientific studying centers have been established at the universities, (e.g., SSSC at MSU).
4. Math classes in ordinary schools (classes with a special curriculum): For example, in one Moscow school, math classes are conducted by the professors at MSU. One should not confuse these classes with those "studying math in-depth" where the pupils from different classes are intermingled.
5. Evening math school in Moscow: Evening school includes study groups with pupils 12

years and older. MSU instructors from the department of mechanics and math accept responsibilities for these groups. The focus of the groups is to discuss the problems used in the Olympiad competitions.

6. Groups operating at "palaces of youth."
7. Summer SPMs: Summer SPMs are organized for the pupils already known in the field (Olympiad prize winners). Pupils have several hours of math in the morning, then elective special courses. The participants can then relax and exercise in sports activities. Travel tours within neighborhoods are usually provided. Team Olympiad competitions and "math fights" are conducted regularly. These Summer SPMs are held in the Vyatka and Krasnodar regions.

Russian Math Olympiad

Five exams comprise the Russian Math Olympiad:

First exam, School Olympiad, is for pupils in grades 5 to 11 (11 years and older). The main object of the School Olympiad is to advance students' interest in math and to encourage them. Problems are designed by employees of city or regional educational institutes. The first two problems should be easy enough for an average pupil to solve. The second exam is the Town Olympiad. This is held in December. Problems are designed by an Olympiad commission in the town. Everyone can participate in the second exam.

The third exam, Regional Olympiad, is held in January during the winter break. Beginning with the third exam, problems are designed by the Russian Olympiad Commission. The Regional Olympiad are held for two days (4 hours per day; 4 problems per day). Only one pupil advances to the next level. From 1986 to 1989 the second day's exam was a "practical exam" where the pupils were allowed to use calculating machines.

The fourth exam, the zone exam, is held in March during the spring break. The whole Russian territory, except Moscow and St Petersburg, is divided into four regions (zones). Regional prize winners arrive for the zone exam along with winners from previous Olympiad. About 25 pupils compete in each age group. The competition lasts two days (4 hours per day; 4 problems per day).

Moscow and St Petersburg hold separate Olympiad, and the rules and procedures are different from those of the zone exam. However, the number of winners is the same — 7 pupils from 9th grade and 5 pupils from 10th and 11th grades. Winners of previous Olympiad are also personally invited.

Until 1992 the fourth exam was the final exam for the Russian Olympiad. The next level of exams was the All-Soviet-Union Olympiad. From 1986 to 1989, the second day of third and fourth exams was for "practical" problems (see Kukushkin & Kuptsov, 1987). (Professor G. N. Yakovlev has been the chair of the Council of the Russian Olympiad for 15 years, while Professor V. V. Vavilov has led the same council for the All-Soviet-Union Olympiad.)

Since 1992 the Russian Olympiad has been held in 5 exams. The problems used in the Russian Olympiad exams have been regularly published in *Kvant* and *Math in School* magazines (see Bukhovtsev, Kukushkin, Kuptsov, Ovchinnikov, & Reznichenko, 1986).

The fifth and final exam is held in April when the winners of six zones gather. These Olympiad exams last for two days (5 hours per day; 4 problems per day). Participants must solve atypical problems. It is difficult to solve these problems. Some problems are solved by only one or two

participants. A number of the problem designers have been working for the Russian and All-Soviet-Union Olympiad for many years. These people are enthusiasts serving to popularize math in Russia.

Ten to twelve pupils are invited to the national team to compete in the International Olympiad, but only six of them actually attend the competition. Usually the national team of Russia or the Soviet Union has had success at the international level. All members of the national team are accepted in any University without taking exams.

Other Competitions

There are many different Olympiad and other competitions in Russia. The list includes the following:

1. City Competitions. Olympiad are held in different cities throughout the Soviet Union (Professor N. N. Konstantinov).
2. Lomonosov competition (Lomonosov was the famous Russian scientist of the 18th century). The range of subjects in this competition is very broad.
3. University Olympiad. Winning such competitions results in acceptance to the university without taking exams.
4. Test-rating Olympiad. "Intellectual marathons," with exams in English, physics, and mathematics.
5. Regional competitions for young mathematicians such as the Ural competition.
6. Festivals for young mathematicians. These festivals are a real celebration for youngsters. Teams compete in math and attend conferences and other activities.
7. Math celebration at MSU for 12- and 13-year-old pupils. The winners of this competition are accepted by the universities' physics and mathematics departments.
8. Soros Olympiad have been held since 1995 (organized by the International Soros Science Education Program). These Olympiad have three exams.
9. Competitions for solving the problems published in *Kvant. Problems of Kvant* contains atypical problems for any age group. There are also competitions for 6th, 7th, and 8th grade pupils that are listed in *Kvant for Young Pupils.*

Publishing Activities

Books containing Olympiad or other atypical math problems are regularly published in the U.S.S.R. Many books by M. Gardner were translated in Russian.

Three series should be noted:

1. *Popular lectures in math* was started by publishing the lectures delivered in MSU study groups.
2. *Library of math study group* started publishing the problems from MSU study groups.
3. Series, *Library of Kvant.* Since 1970 the magazine *Kvant* has contained an ocean of information about Olympiad math. Several employees of *Kvant* were members of the All-Soviet-Union Olympiad jury for many years. Books by Y. I. Perelman on physics and math are of particular interest in Russia.

Successes of Olympiad Winners

Being a winner of the Olympiad is not necessary for having a successful career as a scientist. For instance, the winner of a Fields prize in 1994, E. L. Zelmanov who currently works at Yale University, did not achieve any great success in the U.S.S.R. Olympiad competitions. On the other hand, being a winner of the Olympiad does result in becoming a good scientist. The majority of Olympiad prize winners work in science and education; many are well known in their fields.

Due to changes in the U.S.S.R. (disintegration, migration), it is very difficult to follow the careers of the Olympiad winners. Because of very low salaries, many Russian scientists tend to migrate to foreign countries. Thus their fate is unknown. The data on participants of International Olympiad are described in *Problems of Math Olympiad* (1992). Practically all these Olympians work either in universities or other academic institutions.

A well-known Soviet mathematician, S. N. Mergelyan, the winner of the Olympiad, completed a five-year university program in three years and became a member of the U.S.S.R. Academy of Sciences at the age of 25. Similarly, Y. V. Matiyasevitch, when he was 13–16 years of age, studied with the study group of Leningrad pioneers. In his last year of school he studied in the SPM at MSU. During these years he won the Leningrad, Moscow, and All-Soviet-Union Olympiad several times. He also won the gold medal at the Sixth International Math Olympiad in 1964. Matiyasevitch produced his first scientific article when he was in his second year of college. He solved a research problem that was investigated by three prominent American scientists (H. Putnam, M. Davis, and J. Robinson). Matiyasevitch proposed an atypical and trivial solution to this problem. Most probably his Olympiad background was a great advantage to his development. Matiyasevitch is now in charge of a laboratory at the St Petersburg Math Institute.

G. A. Margulis was trained in the math study group at MSU. He was a prize winner in the Moscow Olympiad, a winner of two All-Russian Olympiad, and a silver medal winner of the Fourth International Math Olympiad. Currently he works at the Institute of Information Transactions. Margulis received a Field prize in 1978 for work on theoretical aspects of Lie Groups. Another Olympian, Suslin, won the gold medal at the Ninth International Math Olympiad. He is the leading scientist at the St Petersburg branch of the Russian Academy of Sciences. He proved the hypothesis of Serre on a projective module above the ring of continuous functions. Still another Olympian, Drinfeld, won the gold medal at the Fourth IMO in 1962 and a Fields prize for success in the theory of representations and the quantum theory of groups. It should be mentioned that his first scientific work was done on the basis of a problem that he solved in the Olympiad.

There are many famous names among the Olympiad winners: N. M. Korobov, V. I. Arnold, V. M. Tikhomirov, Y. S. Ilyashenko, A. Toom, I. Bernstein, S. Husein-Zade, A. Marchenko, I. Krichever, A. Lifshits, V. Kharlamov, A. Razborov. Many of them work in foreign countries: I. Bernstein, D. Bernstein, A. Toom, G. Galperin, G. Blekher, M. Lyubich.

The Leningrad and Russian Olympiad problem designers (S. Fomin, D. Fomin, D. Tamarkin, and others) currently work in the United States. Not every Math Olympian remains in the field of math, however, Tolpigo, who won the gold medal at the Fifth International Math Olympiad (IMO) in 1963, authored a book on Olympiad math, but is now a political figure in Kiev. E. Pankratyev (participant in the Fourth IMO in 1962) works in computerized algebra. He also translated a scholarly work by the American mathematician A. Akritas (see Akritas, 1989). Akritas was a guest at the Olympiad in Ashgabad. Smirnov (silver medal at the Fifth IMO 1963) is the author of a book on problems. Finally, younger generations of Olympians are also

successful. Aleksandrov (silver medal at 11th IMO, 1971) solved the problem of U. Rudin; Konyagin (gold medal at the 12th and 13th IMO) solved one of the problems proposed by Littlewood.

To summarize, the Olympiad movement in Russia was and still is of great importance. The work done is mainly sustained by enthusiasts. Many Olympiad participants achieved great success in life and in science or math. These people have loved math since their childhood. Some of this love is probably the result of the Math Olympiad.

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Biography

Boris Kukushkin is a professor at the Moscow Pedagogical State University and has a long association with the Russian Math Olympiad at several levels. He has written extensively about the Olympiad and is the repository of published and unpublished books, articles and research papers dealing with this competition. He is considered the "historian" of the Russian Math Olympiad.

CHAPTER 8

IMPLICATIONS OF THE OLYMPIAD STUDIES FOR THE DEVELOPMENT OF MATHEMATICAL TALENT IN SCHOOLS

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Abstract

In this chapter educational implications arising from the data about the Olympiad winners in the U.S., Taiwan and Mainland China (Chapters 3–5) are offered. The discussion addresses two lines of questioning: (1) How can we ensure support for recognized math talent through schooling to professional life? (2) How can we increase the pool of gifted students who participate in the Olympiad and other academic competitions and programs? To address the first question, related research studies in a number of different areas are explored. The second part of the chapter looks at how and why schools should expand the number of students who participate in competitions. This view is supported by a rationale for the role of talent development, including whether broad or narrow curricula for secondary students should be pursued and how the "the leaky pipeline" leading to math-based careers can be "plugged."

Introduction

Recent manifestations of gifted and talented education have focused on the development of domain specific talent (Feldhusen, 1995; Gagne, 1995) and both longitudinal and retrospective studies have been conducted in order to explore the variables that lead to fulfillment of great potential within each of the domains (Subotnik & Arnold, 1994). Campbell and his colleagues present data on the backgrounds and experiences of Math Olympiad winners from three countries: the United States, China, and Taiwan, providing insights into educational and child-rearing patterns that enhanced or created obstacles for these extremely able people. In this chapter the educational implications that arise from the materials collected by Campbell (see Chapter 3) on the American winners will be identified. The discussion will address two lines of questioning: (1) How can we ensure support for recognized mathematical talent through schooling to

professional life? (2) How can we increase the pool of gifted students who participate in the Olympiads and similar competitions and programs?

The first question will be explored within the context of the following dimensions of talent development:

— the age at which mathematical talent is manifested,
— the role of parents in nurturing children's abilities,
— the curriculum and ambiance of the secondary schools,
— the opportunities for competition and challenge afforded by the Olympiad,
— the underrepresentation of females on the teams, and
— the post-secondary experience of America's most talented students in mathematics and science.

The second question is addressed in the second half of the chapter. This discussion includes a rationale for the role of talent development in schools, the requisites for talent development, including whether broad or narrow curriculum for secondary students should be pursued, and how the "leaky pipeline" leading to mathematics-based careers can be "plugged."

At What Age Should Talent Development Begin?

Each talent domain has its own trajectory (Baldwin, Colangelo, & Dettman, 1984; Lehman, 1953; Piirto, 1992; Simonton, 1994; Subotnik, 1995). Prodigious performance in some arenas like mathematics, music, chess, and dance can appear early. When it does, disciplined practice and exposure to incrementally challenging material prepares talented individuals to participate maximally in the creative aspects of a domain, as well as to compete with others in contests and award competitions.

Tragically, too many potentially gifted students are held back from learning mathematics at a pace and depth appropriate to their intellectual level. This situation is derived from school policies that are driven by financial constraints, misplaced concerns about equity, poorly conceived curriculum, and under-prepared teachers.

Whenever a boy or girl expresses interest in pursuing a mathematical topic or moving more rapidly through the curriculum, the opportunity should be made available. Grouping students into an advanced or accelerated math program inoculates them from the lure of anti-intellectual school culture and helps to provide a peer group that makes staying in the advanced track attractive (Miserandino, Subotnik, & Ou, 1995). Those classes can then serve as the pool for math team and Olympiad membership.

International differences exist in the proportion of Olympians enrolled in gifted programs during their pre-collegiate years. Forty-three percent of the Americans were identified and placed in these programs as early as elementary school, yet only 14% of similarly aged Taiwanese and no Chinese students chose or were offered that opportunity. By the time they reached high school, however, fully 75% of the Taiwanese Olympians and 65% of the Chinese Olympians were enrolled in special gifted programs. The percentage of American students picked up between elementary and secondary levels was only 14%, with a total enrollment of 57% at the secondary level. One possible explanation for these figures is that in China and Taiwan the math curriculum offered to all students in the early years is rigorous enough to keep young children sufficiently

challenged. In the United States, many elementary school teachers are not proficient mathematics instructors, and providing instruction beyond arithmetic is rare. Only special gifted programs afford a level of mathematics training sufficient to prepare students for competition.

According to Bloom (1985), a successful talent development program includes three stages. The first is the romance period, during which children fall in love with a domain. The second stage exposes youngsters to techniques and rules. It is a time for practice, discipline, acquisition of expertise, and testing one's level of proficiency via competition. Some adolescents lose their commitment to a talent area at this point on the continuum. A peer group or team of similarly interested individuals can counteract this movement by providing social support that reinforces continued participation in a specific domain at this crucial juncture (Astin & Astin, 1992). This is especially important for mathematically talented females who are more likely to continue advanced study of mathematics if other females are present in classes (Casserly, 1980; Casserly & Rock, 1985) or on teams. The third stage of talent development is associated with refining a style and developing a niche. Olympiad students might experience this educational interaction with their graduate school mentors.

Parental Support for the Talent Development Process

For many Olympiad winners, the talent development process began at home. Neither the Olympiad winners nor their parents reported that excessive pressure was placed on the winners to achieve highly. Clearly, there were sufficient intrinsic rewards emanating from participation in the competition to preclude the need for much parental influence. Parents may play more of a support role such as driving students to competitions, providing verbal encouragement, or helping children to manage time and other commitments. Youngsters who derive pleasure from intellectual activity are good candidates for socialization into the world of academic science and mathematics where status and life satisfaction are based on immersion in the life of the mind.

Parental commitment is crucial to the development of these values, yet monitoring the quality and amount of involvement can be difficult. When the attitudes, values, and experiences that students bring with them from home are congruent with those of the mathematics coach or team leader, the combination is dynamic. However, when they are counterproductive, the result can be student burnout or attrition from the mathematics "fast-track."

Greater collaboration between parents and the school assures that students capable of such high levels of performance receive the support required for a rigorous competitive process. The education community must maintain parental connections through all levels of schooling, especially during the secondary years when parental involvement is most likely to drop off. In the United States, the transition from elementary school to high school is a critical crossroad in student academic and personal achievement.

The School Environment

In 1995, 5,495 high schools participated in the 46th American High School Mathematics Examination (AHSME), a 2.2% increase over the previous year. Although the number of contestants (354,420) increased 4% from the previous year, this number represents only 2.4% of

high school students in the U.S. The percentage of females sitting for the AHSME has remained stable in recent years at approximately 45%.

The number of high school students enrolled in the 1995 AHSME is significantly larger than that of the preliminary math competition, The American Junior High School Mathematics Examination (AJHME). The 1995 AJHME competition included only 199,314 students in grades 5 through 8. The lower levels of participation in the AJHME, compared to the AHSME, may be attributed to the wide variability of what is offered to students as a result of debates over curriculum reform.

The pipeline can be said to increase its flow 78% from the junior to the senior levels of mathematics competition. This increase may reflect the recent commitment of schools to further enrich opportunities for students in the areas of science and mathematics. For example, many of the awards given by the Department of Education under the auspices of the Javits Gifted and Talented Act have been targeted at increasing girls' and other under-represented groups' interest and success in mathematics and science. In addition, the National Council of Teachers of Mathematics has taken a very active role in encouraging increased participation in math competitions and in raising national standards for mathematics achievement (NCTM, News Bulletin, March 1996). Recent studies on single sex education (Subotnik & Strauss, 1995), the role of mentoring (Arnold & Subotnik, 1995), and the benefits derived from domain specific homogenous grouping (Miserandino et al., 1995) offer interventions to support more successful participation by females and other under-represented groups in mathematics.

These programmatic initiatives must be expanded into the elementary schools so as to channel more students into mathematics and science extracurricular activities such as competitions and clubs. Increasing the involvement of parents in this effort through programs like Family Math enhances the potential for early identification of talented students and the likelihood that families will view mathematics as both useful and creative (Stenmark, Thompson, & Cossey, 1986).

Not all the Olympiad winners were in special school programs. However, participating in the Olympiad process allowed for opportunities to meet, compete, and compare oneself with other very bright students who shared a deep interest in mathematics. Membership in a group that values intellectual and academic pursuits can be especially important in schools where the climate is distinctly anti-intellectual. Students who experience being ostracized or harassed by classmates can find comfort in the company of fellow Olympiad participants.

According to social comparison theory (Festinger, 1989), students develop their academic self-concepts by contrasting their abilities with those around them. If students perceive themselves to be the most skillful mathematics students in the school for most of their school careers, their academic self-concepts are likely to be very high. However, without competition or great intrinsic motivation, they are less likely to know the full extent of their capabilities. Learning to equate effort with achievement is an important lesson too often missed by those who are never sufficiently challenged, and results in the belief that anything requiring discipline or persistence is "boring," or indicative of mediocre ability.

Finally, schools can increase student involvement with mathematics through staff development. This can be accomplished in three ways: attending to the in-service needs of teachers (Ball, 1993; Lampert, 1990); changing faculty culture regarding attitudes toward mathematics instruction, grouping, and acceleration (Cobb, 1994; Peterson & Barnes, 1996; Resnick, 1989); and developing collaborative relationships with university-based teacher education programs. The focus of professional development should be on both increasing teachers' level of competence in mathematics and their knowledge about how to identify and

develop mathematical talent. Linking professional development with university collaborations will also provide opportunities for teachers to gain greater competency in mathematics, creating for them a larger "community of learning" and support network (Miserandino et al., 1995; Peterson & Barnes, 1996). This community can especially broaden the success of the talent development experiences like the Olympiads for mathematically gifted students not yet being served. The biggest pool of untapped talent is that of girls who are not succeeding at the very top levels of the competition.

Increasing Female Participation

Gender differences in secondary mathematics achievement have been diminishing except among the mathematically most talented (Benbow & Stanley, 1983; Callahan, 1991; Coley, 1989; Fiengold, 1988; Linn & Hyde, 1989; Wilder & Powell, 1989). A body of literature has been accumulating to explain these results.

Female under-representation in the ranks of international-level Olympiad winners is notable. There were only two female participants in the entire history of the American Olympaid team, and no African-Americans or Latinos. Schools, families, and female students themselves must contemplate the sources of girls' lack of participation. Course placement and selection in secondary and middle schools certainly has an impact on exposure to and challenge from mathematics content. By the end of high school, boys substantially exceed girls in the number of math courses taken (Astin, 1993). Girls are also less likely to hold high expectations for their success in highly demanding mathematics environments (Lent, Lopez, & Bieschke, 1991), even when ability differences are not apparent (Betz & Hackett, 1983; Campbell & Beaudry, 1996). Lowered self-concept in mathematics is associated with fear of trying alternative solutions or shortcuts, preferring to follow "recipes" or fixed sequences of problem solution (Grieb & Eisley, 1984; Linn & Hyde, 1989; Mura, 1987; Wilder & Powell, 1989). Given that secondary school mathematics grows increasingly complex, competent math learners need to operate comfortably with mathematical principles at each grade level to avoid relying on memorized formulas (Blais, 1985; Davis, 1984; Schoenfeld, 1985), to think flexibly, and to make broad and rapid generalizations (Krutetskii, 1976). Clearly, in order to become more autonomous learners, a key to expertise and creative productivity in mathematics, females must engage confidently with the challenge of mathematical problem solving (Campbell & Beaudry, 1996; Fennema & Peterson, 1985).

Too often adolescent girls remain unconvinced that mathematics and science will be useful to their long-term goals (Linn & Hyde, 1989). In fact, according to the literature exploring gender differences in science and mathematics achievement and retention, males tend to value mathematics and science more dearly than females, particularly beyond the elementary school years (Betz & Hackett, 1983). Females who are highly talented in both verbal and mathematical areas are more likely to choose nonquantitative rather than quantitative college majors and career fields (Lubiniski, Benbow, & Sanders, 1993; Stocking & Goldstein, 1992; Olszewski-Kubilius & Yosumoto, 1995). Their choices for summer enrichment programs reflect a clear preference for verbal subjects.

Teacher behavior and student-teacher interaction is another potential influence on gender differences in mathematics achievement. The largest number and highest quality of teacher interactions in mathematics and science classrooms have been reported to take place with a

small number of students, most often high achieving males. Furthermore, female classmates and peers exert pressures to value popularity over commitment to academic excellence (Smith, 1992). Male students may believe mathematics is more a male domain (Olszewski-Kubilius & Wohl, 1993) and therefore females are less able to participate in advanced work in the area. The classroom environment, therefore, has been found to encourage males and to discourage females from achieving excellence in mathematics (Becker, 1981; Good, Sikes, & Brophy, 1973; Hart, 1989; Karp & Yoels, 1976; Orenstein, 1994; Sadker, Sadker, & Long, 1989; Tobin & Gallagher, 1987).

Urging students, particularly females, to take a stab at a problem by welcoming educated guesses, or by encouraging students to work together in small groups composed of more than one girl in each group, may assist in increasing females' confidence in their mathematical prowess (Lockheed & Harris, 1984; Treisman, 1985). A strong sense of self-efficacy makes individuals more resistant to withstand failures and obstacles encountered along the way (Orenstein, 1994).

How Colleges Address the Needs of Talented High School Students

The talent development model employed by athletic associations, conservatories, or dance academies offers notably gifted individuals an individually tailored program to enhance their abilities and extend their competitive status. The program includes placement with a special coach or teacher and a practice schedule created to strengthen needed weak points and feature obvious strengths. The most able of those admitted to such programs come out identifying strongly with their talent domain, and are more able to use their gifts to achieve great performance and creativity.

In contrast, students who achieve great recognition for their abilities in academic domains such as mathematics and science are too often allowed to progress unattended during their first two years of college. They may choose prestigious institutions that admit students of high caliber in various domains, thus becoming one of many freshmen "stars." Operating without a mentor or someone who can take a personal interest in their progress increases the likelihood that the notoriously unpleasant science/math pedagogy of the first two years (Seymour & Hewitt, 1994) will weed them out. In fact, some members of the 1983 cohort of Westinghouse winners studied by Subotnik and her colleagues (Subotnik, Duschl, & Selmon, 1993; Subotnik & Steiner, 1994) left large and impersonal classes to enjoy the humanities. Since the Olympiad team is composed of only six people, society should ensure that each one of them that wishes to pursue mathematics, science, or technology is guided to the most suitable teachers, peers, and technology in the post-secondary institutions they attend.

Where Do the Needs of the Gifted Fit into the Current Educational Climate?

In the history of education literature, the metaphor often used for the public schools is the factory model (Kleibard, 1975). Individuals learned punctuality, followed directions to achieve prescribed goals, and accepted where they belonged in the academic hierarchy. Children who demonstrated extraordinary aptitude were generally skipped through grades. Only those with the most potential or with the highest socioeconomic levels attended secondary schools.

Today's education reform movement has distanced itself from the undemocratic factory model of schooling by shifting the focus of attention to creating classroom communities; greater emphasis is placed on social development and skills. How are students with academic talent to be accommodated in this climate of reform? Some regions or localities recognize the special needs of students who are outside the academic mainstream. They maintain or create programs designed to provide gifted students with challenging coursework and peers, allowing them to advance through the curriculum with their age and ability mates. A smaller number of schools follow the earlier tradition of skipping students who demonstrate above grade level mastery. Finally, a growing number of school districts are expecting talented students to share their abilities with heterogeneously grouped classmates and teachers are expected to meet the educational needs of a very diverse group of learners. The main source of resistance to this "detracking" movement is in secondary mathematics. Because of the sequential nature of the material offered in mathematics classes, varying levels of content acquisition and mastery are clearly visible to trained professionals. Secondary mathematics teachers tend to therefore support ability grouping (Grossman & Stodolsky, 1995). The response to ability grouping at the elementary and middle school levels is much more ambivalent.

Requisites for the Fulfillment of Talent

Walberg's (1988) nine factor model, described in Chapter 1, enhances our understanding of how the intellectual acuity of the winners interacts with parental, educational, and peer support to result in maximum learning. Tannenbaum (1986) also delineated factors that lead to the fulfillment of a gifted child's promise: general intelligence, specific talent, environmental support (Walberg's parental, educational, and peer support), conducive psychological characteristics such as high motivation and drive, and chance factors. For different talent domains, different threshold levels of each factor might be sufficient, but all must be in place in order to transform potential into creative productivity or eminence.

General intelligence refers to IQ-type problem solving skills. There are no IQ data available on the Olympiad winners, but given their stellar school performance (63.5% were in the top 10% of their class; 24% in the top 1%), one can assume that their IQs were reasonably high. Specific talent is demonstrated by their high scores on the Olympiad exams and their competing successfully in this competition exhibits their drive and motivation. Parents prepared the Olympians for the competition and offered support; the schools supplied the program and the competition supplied the peers and the social support. Finally, chance factors such as the economy influence available sustenance in post secondary education and careers. For example, the 1983 cohort of Westinghouse winners followed by Subotnik and her colleagues (Subotnik & Steiner, 1994; Subotnik & Arnold, 1996) are currently 30 years old. Many of these highly talented and superbly trained individuals are struggling with a tight market for scientific jobs, particularly in academic research, the arena where many dreamed of finding a professional home. Furthermore, their choice of college, often made on the basis of name rather than intellectual fit, and the availability of mentors have an impact on whether gifted individuals pursue quantitatively based careers.

Narrow vs Broad Training

Many educators and parents fear that adolescent preoccupation with a talent will hamper youngsters' social development. In Bloom's (1985) study, subjects spent approximately six hours

a day during their school years in practice or study. Preparing for participation in the Olympiad also requires a serious commitment of time on the part of the competitors.

Eminent individuals in every field exhibit rigorous discipline and devotion to the pursuit of excellence (Ochse, 1990; Subotnik, 199.5; Subotnik &Arnold, 1995; Subotnik, Kassan, Summers, & Wasser, 1993). Although Olympiad winners were actively involved in many high school activities, they had to sacrifice some dimensions of their lives in the name of successful international competition. In fact, not all the Olympiad winners pursued or expected to pursue careers in science or mathematics. Participating in the program did not preclude involvement in a liberal arts curriculum or extracurricular activities. The discipline and confidence needed to achieve such a high level of competitiveness in mathematics is certainly applicable to achieving in any high-status or creative field.

The Science/Mathematics Pipeline: Where Does It Begin?

The pipeline leading to deep commitment and interest in mathematics begins in elementary school. Students who are exposed to concepts and topics beyond computation get a much more complex and accurate picture of the discipline. Those students who, for example, find visual/logical reasoning more compelling than verbal/logical reasoning could be engaged by topology, geometry,.and some aspects of number theory. Furthermore, teachers who are well prepared and confident in their mathematical learning can enjoy and model creativity in problem finding and solving.

The pipeline starts to leak in middle school when children begin their engagement with abstract reasoning in mathematics. Those who had a rich elementary school experience should be able to adapt well to the challenge. Depending on how a student performs in sixth- and seventh-grade math, he or she will be placed in an algebra or pre-algebra class, and those who take algebra earlier are more likely to have room for a calculus course before they graduate, opening up opportunities for advanced studies in college.

Although reading level is the gauge for determining “smartness” in elementary school, math placement is the key to determining smartness in the middle and high school. The ramifications for placement in a top level class are great for academic self-confidence. Furthermore, mathematics and the sciences, particularly the physical sciences, project an impression of superior academic rigor that can be especially attractive for many intellectually gifted students, boys in particular. At this point, social pressure, gender stereotypes, and competing interests in other domains such as sports, music, and the humanities, may draw talented females and under-represented minorities from enrolling or being selected into the top mathematics track.

Conclusion

The Olympians are a very select group of students, yet their achievement stands as a benchmark for all gifted students. Clearly, individuals with special interests or talents in mathematics need to be identified as early as possible and supported and challenged by their teachers throughout their formal school experience. Many lines of inquiry are worthy of pursuit including how the learning that occurs in preparation for the Olympiad exams compares to the instruction received in class.

Research on participants in the International Mathematics Olympiads suggests that the experience of high-level competition influences major life choices. Preparation for the Olympiad embeds mathematically talented youngsters within a social context that supports their intellectuality and achievement. The study of those conditions helps to delineate aspects that are especially conducive to replication in other settings, in other domains, and with other groups of learners. The Olympiad model has implications for talent development broadly conceived that can contribute to current discussions of school reform and restructuring.

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CHAPTER 9

A CROSS-CULTURAL ANALYSIS OF SIMILARITIES AND DIFFERENCES AMONG MATH OLYMPIADS IN CHINA, TAIWAN, AND THE UNITED STATES

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Abstract

This chapter explores the cross-cultural similarities and differences of Math Olympians and their families from China, Taiwan, and the United States. Multiple theoretical perspectives are used with these comparisons. The results of these analyses suggest that there are more areas of difference than similarity among these Math Olympians. These differences are largely due to cultural factors emanating from philosophical beliefs and evolving political factors revolving around two major concepts: individualism versus group collectivism and intrinsic versus extrinsic factors.

Introduction

In recent years, international comparisons of student academic achievement have intensified the debate surrounding the meaningfulness of the results and its implication for economic development. Similar to the 1950s when the Soviet Union launched the space probe Sputnik that catalyzed an educational reform movement to increase the talent pool of American scientists and engineers, recent international academic comparisons have once again raised concern among policymakers about their nation's ability to compete in the global marketplace.

United States economists worry that poor performances in international academic competitions may have dire long-term consequences for America's ability to compete in a global economy (Mandel, 1995). Contrary to the concerns of U.S. economists, a recent report indicates that the U.S. economy is the most competitive in the world (Behr, 1994). This finding has implications for the meaningfulness of international academic competitions. In particular, do the results of international academic comparisons accurately reflect a country's ability to compete in technical areas? Bracey (1995) contends that the rhetoric and politics surrounding international comparisons often create misinterpretations that raise questions about the meaningfulness of the results.

To illustrate the discontinuity between international academic comparisons and competitiveness in technical areas, American thirteen-year-olds ranked 13th out of 15 countries in science in the Second International Assessment of Educational Progress (IAEP-2). During the same timeframe, a 1995 report from the National Science Foundation indicated that the number of science and engineering doctorates awarded in United States universities has grown to an all-time high of 26,515 (The Chronicle of Higher Education, 1996). What explains the differentiation between results obtained during international academic competitions and subsequent academic technical productivity? Are there cross-cultural factors that transcend meaningful explanations of academic results to future productivity in technical areas?

The purpose of this chapter is to examine the cross-cultural similarities and differences of Math Olympians and their families from China, Taiwan, and the United States. Of particular interest are the differences found between countries and the possible explanations underlying them. To provide direction for the cross-cultural analysis, the data were examined from multiple theoretical perspectives (e.g., individual/group, internal/external). Comparable variables were scrutinized for differences and examined for possible explanations. Specifically, were identifiable differences among Math Olympians attributed to cultural factors or were they due to noncultural factors (e.g., measurement)? This chapter focuses exclusively on cultural factors.

By incorporating a cross-cultural analysis and perspective, interpretations can be skewed if viewed from an ethnocentric perspective. As an example, what one country values may not be as important to another country (e.g., individual expression, patents). For that reason, it was imperative that caution and appropriate methods (such as triangulation) were used to insure that cross-cultural analyses produced meaningful interpretations.

Similarities and Differences

Based on the data, five areas were identified as major sources for cross-cultural similarities and differences: family processes; self-concepts, attributions and perceptions; gifted and talented (G/T) programs; available resources and skills of Olympians; and academic productivity. Each area is examined separately.

Family Processes

In general, Math Olympians were raised in small families (i.e., less than two children on the average). Although the birth order of Math Olympians varied (i.e., first-born, second-born, etc.), first-born Olympians were most represented except in China. Chinese Olympians were most represented by second-born children. The Chinese representation of second-born Math Olympians may be influenced by national policies on childbearing practices, which limit the number of children families may have. A related finding within the U.S. sample shows that most of the Olympians were the grandchildren of immigrants (i.e., third generation).

Another family characteristic focused on the issue of family history and heredity. Chinese and American Olympians were more likely to have distinguished family members (e.g., parents who had higher occupational status and educational achievements) than were Taiwanese Olympians. In particular, Taiwanese mothers had significantly lower levels of occupational and educational achievement. This result has implications for the caste system that Ogbu (1978) addressed in his

thesis on the education of minorities in developed and underdeveloped countries. In particular, are the Chinese and American educational systems more caste oriented than the Taiwanese system? And if so, what impact does this have on the science and engineering pipeline?

From a parental perspective, issues involving intellectual development, parental help, and psychological support were similar for all Olympians. Family process issues appear to be consistent across countries except in the areas of parental pressure and parental monitoring. Chinese and Taiwanese parents applied more pressure and kept a closer eye on the progress of their child than parents from the United States. This difference may be a cultural reflection of the degree of child independence afforded by parents and the role of the family in the educational process. As Shaw (1991) found, individuality is not separated from society in the Far East. The extended family structure exudes a degree of influence in the lives of Taiwanese and Chinese children that is not matched on a large scale in the United States.

Self-concepts, Attributions, and Perceptions

As Campbell and Wu (1996) addressed in Chapter 1, the purpose of national competitions like the Math Olympiad is to identify gifted students, to motivate and nurture a child's talent, and to increase the flow of talented young people into the science and engineering pipeline. In addition, educators and policymakers must monitor the psychological effects of program participation on exceptional children.

Self-concepts

Based on the data available, U.S. Olympians had higher self-concepts in math and science than Chinese and Taiwanese Olympians. These results suggest cultural differences between Western and Far East societies. For Chinese and Taiwanese students, this finding is consistent with prior research indicating that personal satisfaction with performance is low and negatively correlated with achievement in Far East countries (Hofer, Carlson, & Stevenson, 1996). Another explanation may be American students' participation in gifted and talented programs. This finding would be consistent with Festinger's (1954) social comparison theory and Marsh's "big-fish-little-pond" effect (Marsh, Chessor, Craven, & Roche, 1995).

With U.S. Olympians, concepts such as self-expression and individuality are encouraged, while in China and Taiwan the same concepts are suppressed by the norms of society. Using Marsh's analogy, Far East countries tend to view individuality and self-expression from the little-fish-big-pond effect instead of from the Western philosophy of big-fish-big-pond effect. Another way to capture the psychological suppression of individual achievement in the Far East is to visualize the metaphor, "the nail that sticks up gets hammered down." Unlike Western societies where individuals are encouraged to stick out like a nail, Far East societies view the nail as a troublesome nuisance requiring the hammer to bring about conformity to societal norms.

Attributions

Unlike prior cross-cultural research on attributional theory (Shaw, 1991; Lee, Ichikawa, & Stevenson, 1987; Stevenson, Chen, & Lee, 1993), the results indicate that Chinese, Taiwanese,

and U.S. Olympians had similar views toward the attributions of effort and ability. Although Olympians from each country identified effort over ability as the critical attribute, Chinese Olympians indicated the widest divergence between effort and ability, followed by U.S. and Taiwanese Olympians. The Chinese and Taiwanese results are consistent with earlier findings that learning is a result of effort rather than innate ability. It also suggests that Asian countries do not place a psychological label on an individual's ability to learn based on innate characteristics.

The major difference with prior research on attributional theory emanated from the U.S. responses. In past studies (Stevenson et al., 1993), U.S. students generally identified ability over effort as the critical attribute. This finding suggests that U.S. gifted and talented students may have a different view toward attributional theory than was previously thought, especially in later educational years (i.e., undergraduate and graduate work).

Perceptions

In assessing the perceptions of Olympians toward school hindrances and a conducive home atmosphere, there was widespread consensus across countries. These findings suggest that the perceptions of gifted and talented students toward school hindrances and the home environment may cut across cultures. In general, schools were perceived by Olympians as places where teachers and the school environment did little to hinder their academic growth.

A slightly different picture emerged from the perceptions of Olympians toward their home environment. Overall, Olympians had a satisfactory view of their home environment in terms of conduciveness toward learning. At the same time, there was inconsistency between Olympians' and their parents' perceptions. In particular, parents of Olympians had higher perceptions of the home environment than their children. This finding indicates a lack of common understanding between what parents and their children perceive as elements of a conducive home atmosphere. This lack of a common perception of the home environment may represent grounds for future research.

The last area of perceptions dealt with the issue of hostility and claims of elitism toward Olympians. Chinese and Taiwanese Olympians reported lower levels of hostility and claims of elitism than U.S. Olympians. These results support earlier explanations of societal differences stemming from Western emphasis on self-esteem and individual success, in contrast to the more Confucian ideals of group collectivism in Far East countries (Hofer et al., 1996). In Western societies where individual accomplishments and self-expression are encouraged, students who are likened to the nail (in the nail/hammer metaphor) are often segregated and ostracized. In contrast, since students in the Far East are expected to conform to the greater expectations of a homogeneous society, issues of hostility and claims of elitism are culturally suppressed. As Shaw (1991) wrote:

> . . . a culture where individual differences are downplayed and collective achievements emphasized, indicates that although differences among students exist, they are not cause for failure when an environment is provided in which success is the norm for all students (p. 118).

Gifted and Talented (G/T) Programs

There were fundamental differences regarding the identification of gifted and talented students and the programs Math Olympians experienced in their respective countries. In general, Math

Olympians from the United States were identified in preschool as gifted, while Math Olympians in China and Taiwan were identified later in the educational process and over a wider range of years (i.e., elementary and middle school years). As a consequence, U.S. Olympians graduated from high school earlier than their Chinese and Taiwanese counterparts.

The differentiation in G/T identification reflects a cultural divergence in parental and educational views towards accommodating the needs of students. In the United States, parents often initiate early testing of their children for academic talents, while in China and Taiwan academic precocity is initiated by school authorities after several years of observation and academic performance. This result indicates a cultural difference in the way parents view school authorities. In Far East societies, school authorities are accorded great respect (rarely challenged by parents) and viewed highly in terms of occupational status (in contrast to their counterparts in the United States).

Another cultural difference concerns the educational philosophy of early segregation. In the United States, ability tracking is used as an instructional method to create homogeneous groups of individuals in terms of their ability. Although ability grouping has produced inconclusive evidence and is not politically popular among various educational groups in the United States, many students are ability grouped very early in their academic careers. In contrast, the Chinese and Taiwanese educational systems view education as a holy mission where every person has the ability to perform this mission. Schools in China and Taiwan aim for the collective success of all learners and stress conformity to group performance rather than individual performance. The divergent views between Western and Eastern philosophies are reflective of the respective political systems within each country. In China, and to a lesser extent in Taiwan, the political philosophy of socialism affects all aspects of life including educational perspectives.

In reviewing G/T programs, the cultural divergence was most evident at the college level where U.S. Olympians had more opportunities to participate in special programs and mentorships than their Chinese and Taiwanese counterparts. It appears that participation in the Olympiad program produced greater psychological benefits (i.e., better attitudes toward math and science) for Chinese and Taiwanese Olympians than for U.S. Olympians. Since U.S. Olympians have more opportunities to participate in special programs and mentorships, there is reason to believe that U.S. Olympians may have a heightened self-concept toward math and science. Using this line of reasoning, U.S. math and science attitudes would not be as drastically affected by Olympiad participation since U.S. Olympians had better self-concepts toward math and science beforehand.

Despite having more positive attitudes toward math and science, Taiwanese Olympians experienced higher burnout rates than U.S. Olympians. This result may be attributable to Far East societal pressures of conformity and high expectations. The U.S. Olympians reported higher rates of negative consequences associated with the Olympiad program. This finding may be related to their heightened self-concepts and lower attitudes toward math and science as addressed above.

Available Resources and Skills of Olympians

In turning to available resources and skills of Olympians, the cross-cultural analysis suggested that the availability of books in the home environment and the ability to play or be exposed to

musical instruments were common experiences for all Olympians. This was not the case for home computers. Approximately 75% of American and Taiwanese Olympians owned a computer, while only 11% of Chinese Olympians had home computers.

Chinese and Taiwanese Olympians spent most of their computer time playing software games, while American Olympians identified word processing software as the most frequently used. This finding has implications for communication and self-expression. In particular, 71% of American Olympians versus 22% of Taiwanese Olympians and none of the Chinese Olympians had access to electronic mail. This finding supports the perception that countries in the Far East are more internally oriented and closed in terms of communicating outside their societal boundaries.

Another area of divergence was represented by the number of foreign languages Olympians spoke at home. Chinese and Taiwanese Olympians were more likely to be bilingual than American Olympians. This result also points to the relative importance that each society places on foreign language acquisition.

Finally, American, and to a lesser extent Taiwanese, Olympians had more material possessions than Chinese Olympians. This material difference appears to reflect the political system (i.e., socialism versus democracy) and sociocultural values of each country. The responses from Taiwanese Olympians may be indicative of the political autonomy being sought by Taiwan from China. This may also explain why many of the responses from Taiwanese Olympians appear to be a buffer between the American and Chinese responses.

Academic Productivity

Of all the issues addressed in this chapter, academic productivity produced the most evident area of cultural divergence among China, Taiwan, and the United States. U.S. Olympians were the most productive academically in terms of extrinsic factors. Of the 744 exhibits of academic productivity (i.e., articles, books, research papers, and patents), U.S. Olympians were responsible for 739 or 99.32%. This finding highlights the differing perspectives of academic productivity across cultures and supports earlier cultural explanations addressing the Western philosophy of individualism and expression versus the Eastern philosophy of group conformity and suppression.

In the United States, extrinsic productivity and individual self-expression are ways to validate one's accomplishments. By contrast, Chinese and Taiwanese Olympians view personal accomplishments such as academic productivity as secondary to community or societal accomplishments. The lack of academic productivity by Chinese and Taiwanese Olympians is reflective of societal pressures to suppress external displays of personal accomplishment. For Far Easterners, displaying one's personal accomplishments is not viewed in the positive manner of Western culture. Instead of providing validation of one's work, extrinsic productivity and overt display are viewed as signs of selfishness and low self-esteem.

Another aspect of academic productivity involved the issue of mentoring. Forty-six percent of U.S. Olympians, 9% of Chinese Olympians, and none of the Taiwanese Olympians received guidance during their undergraduate program. On the surface, this result might indicate that mentoring is not an important element of the educational process in China and Taiwan. On the contrary, in group-oriented societies such as China and Taiwan, the mentoring process may be more peer than seniority oriented.

Further examination of the 739 U.S. produced articles, books, research papers, and patents

show that 679 or 91.88% were produced by Olympians who were supervised by senior colleagues. This result is consistent with prior research on the benefits of supportive working relationships between junior and senior colleagues (Kram, 1985). It also validates the value of working collaboratively versus individually.

Conclusions

Comparisons of the United States with China, Taiwan, Japan, and Korea have increasingly focused on academic performance and its effect on productivity in the applied sciences. Western policymakers have been particularly concerned with the potentially negative effects that international academic performance might have on technical output.

The cross-cultural analysis shows that there are more areas of difference than similarity among Math Olympians from China, Taiwan, and the United States. These differences are not always dichotomous between the Far East (China and Taiwan) and West (United States). Many of the differences can be attributed to cultural factors emanating from philosophical beliefs and evolving political factors. In general, Taiwanese Olympians appeared to be mid-way between the Chinese and American Olympians. This pattern may be partially explained by Taiwan's quest for political autonomy from Mainland China. The political conflict between Taiwan and China appears to be moving Taiwan gradually away from their Chinese relatives toward more Western ideas.

Beyond political factors, most of the cross-cultural differences between China, Taiwan, and the United States revolved around two major concepts: individualism versus group collectivism; and intrinsic versus extrinsic factors. In the United States, success in school is often associated with individual accomplishment and extrinsic factors. In contrast, conformity to societal pressures plays a major role in explaining the perspectives of Chinese and Taiwanese Olympians toward school success and extrinsic factors. For Far East societies, the intrinsic value of an accomplishment is more important than its extrinsic value. Consequently, it is imperative that care be taken when comparing indicators of productivity across cultures. Based on the data, it is safe to infer that China and Taiwan do not place the same value on the types of academic productivity (i.e., articles, books, research papers, and patents) as does the United States.

To illustrate this point, U.S. Olympians were overwhelmingly more productive than Chinese and Taiwanese Olympians using Western standards of academic productivity. What does this mean for programs like the Math Olympiad that attempt to enhance the science and engineering pipeline in each country? Based on data, the long-term benefits appear to be positive. To some extent, all Olympians benefited in some way from program participation. Of particular note was the positive psychological effects for Chinese and Taiwanese Olympians. The Olympiad experience opened new doors for Olympians from China and Taiwan. For U.S. Olympians, Western indicators of academic productivity appear to validate the external success of the Olympiad program.

In conclusion, the results of this cross-cultural analysis indicate that there are more ways than one to satisfy the need for technological talent. Subsequently, each country must work within the framework of their culture to meet their technological needs. Duplicating efforts of another country without taking into consideration cultural factors is likely to result in disappointment and social turmoil.

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Biography

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SUBJECT INDEX