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 the following countries: United States, Taiwan, China, Japan, 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) that are summarized in separate chapters and is also used in the descriptive reports and analyses presented in the other 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, and 8% have doctorate degrees (National Science Foundation, 1996). The important question is how can a country 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 work force. 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)

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 the top 40 (finalists) are then invited for a series of interviews in Washington, D.C. 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 winners (finalists and semifinalists). Their research skills are especially applicable at institutions that are committed to original research studies.

Over the 54-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 Westinghouse winners. There has been no comprehensive follow-up study to ascertain the number of the Westinghouse winners 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 winners.
The International Science and Engineering Fair is the largest research paper competition. In 1995 this competition reached 1,021,936 high school students (grade 9-12). This competition is organized with local school fairs, regional, state fairs and one 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 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 involve testing of select groups of high school students. One of the largest testings is the National Merit Exam. Many highly talented high school students take these exams and win scholarships with their high scores. Another national program (Study of Mathematically Precocious Youth--SMPY) tests 7th-grade students with the SAT-M exam (Scholastic Aptitude Test Math test). This program invites schools to test their top math students. These testings identify the most talented math students. The SMPY program provides year-round activities and summer programs to help in developing this talent.

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

Rationale behind Competitions

All of these national competitions operate under the following rationale:

1. Identify students with exceptional talent during their formative years.
2. It is assumed that the competition itself will motivate the early development of the child’s talent.
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? To answer these questions we selected the contest that could reasonably be evaluated by our international team. Since the larger contests do not exist in any of the Asian countries, we limited our focus 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 participation in a series of retrospective studies.

Theoretical Framework

An educational productivity model was proposed by Walberg (1984a, 1984b,
It linked nine factors and predicted positive changes in student cognitive and affective achievement. The model has the following components: Aptitude (ability, age, motivation), Instruction (quality of instruction, quantity of instruction) and Environment (home, classroom, peers, television).

The productivity model is illustrated in Figure 1.1. This causal model depicts direct influences (double arrows) 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. In 1976 Walberg and Marjoribanks analyzed numerous research studies dealing with achievement within the frameworks of 12 analytic models. The most complex of these models contains five causal factors. In 1982 Iverson and Walberg synthesized 18 of the most important studies involving 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 model tests use 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, 1995; Campbell & Wu, 1995; Flouris, Calogiannakis-Hourdakis, Spiridakis & Campbell, 1995; Pittyanuwat & Campbell, 1995). 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 was collected.
2. The model was then used 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 the math and science self-concepts, the general self-concept, and two attribution factors (effort, ability).

References


National Science Foundation (1996) Personal communication.


