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# A 10-YEAR LONGITUDINAL FOLLOW-UP OF PARTICIPANTS IN A FAST-PACED MATHEMATICS COURSE

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Students who participated in a fast-paced mathematics course for highly mathematically talented students were surveyed 10 years later, at approximately age 23. Areas considered were (a) undergraduate experience, (b) graduate experience, (c) attitudes toward mathematics and science, and (d) self-esteem. Participants attended more prestigious undergraduate colleges than did nonparticipants. Participants were more likely to attend graduate school than were nonparticipants; this finding stemmed from differences among females. Self-esteem ratings, although high for both groups, were found to be higher for students who qualified for the class but did not participate. Attitudes toward math and science were equivalent between the two groups. Overall, participation in the fast-paced mathematics classes of the Study of Mathematically Precocious Youth (SMPY) was associated with stronger undergraduate education for all students and with more advanced education among females. The fast-paced classes caused gifted students no harm.

Although not all youths who reason exceptionally well mathematically can be expected to become eminent mathematicians and scientists, it seems reasonable to believe that such children's talent would make them especially well qualified for high achievement in such areas (Horowitz & O'Brien, 1986; Kuhn, 1970; Mumford & Gustafson, 1988). Feldhusen (1989) has argued, however, that if gifted children spend too much time in school encountering new material at too slow a pace or being instructed in things they already know, they will lose the motivation to achieve. Whitmore (1980) and Zilli (1971) have also reported that boredom, poor classroom performance, and a denial of the value of academic studies result from an understimulating curriculum. Further, Dweck and Elliot (1983) have shown that motivation to achieve grows when individuals are exposed to educational experiences matching their capabilities; Locke, Shaw, Saari, and Latham (1981) have demonstrated that challenging goals raise both motivation and performance. Thus, providing appropriate educational experiences seems to be critical in determining the extent to which giftedness becomes high achievement (Benbow & Arjmand, 1990).

Because learning opportunities in a regular classroom are designed to meet the needs of average students, they do not challenge or even match the capabilities of gifted students. In offering its first two fast-paced mathematics classes in 1972 and 1973, the Study of Mathematically Precocious Youth (SMPY) attempted to remedy

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this situation by matching the classwork to the ability level of the gifted participants. We now report on the status, 10 years after the class was conducted, of students who attended SMPY's fast-paced mathematics program and a comparison group of qualified students who did not attend the class.

Although fast-paced classes are but one option for meeting the learning needs of gifted students, thousands of students have been involved in such classes since 1972. Moreover, the rapid-pacing concept has been expanded beyond mathematics to fields such as science and Latin (Stanley & Stanley, 1986; Van Tassel-Baska, 1983) and beyond summer courses to in-school programs (e.g., Lunny, 1983). All such programs, however, have been based on the model provided by the first two SMPY mathematics classes.

*Background and Early Evaluation Results*

The first two SMPY mathematics classes have been named "Wolfson I" and "Wolfson II" in honor of their instructor, Joseph Wolfson (Fox, 1974; George & Denham, 1976). Students were selected for these classes by scoring in the top 1 percent of the nation on standardized aptitude and achievement tests. Thus, they were a highly gifted group. Using a lecture format, the pace of the classes was geared to the level of the ablest students; it was, therefore, rapid and challenging. The goal of the fast-paced students was to progress through all of algebra 1, algebra 2, plane geometry, trigonometry, and analytic geometry in less than 14 months, chiefly on Saturday mornings. This goal was possible because of the fast speed of the classroom instruction and the extensive homework completed by students between Saturday meetings.

In addition to the fast-paced class, a self-paced class was developed. This self-paced class was composed of students who expressed difficulty in maintaining the pace of the fast class or who scored high on the standardized test administered at the end of algebra 1, but low on the test given after algebra 2. Therefore, the students who remained in the original fast-paced group were the best of the best. The goal of the self-paced students was to complete algebra 1 and algebra 2 in 12 months, primarily on Saturday mornings. Thus, the self-paced group was more rapidly paced than are math classes in typical schools. For further details regarding the class structure in both treatment groups, see Fox (1974) and George and Denham (1976).

Mastery in each subject area was assessed with standardized achievement tests. The teaching of the class was not geared toward these tests, however. Scores on the standardized tests were high; for example, 10 of the 11 students who were enrolled in the Wolfson I fast-paced class at the end of algebra 2 scored at or above the 98th percentile on national high school norms (Fox, 1974). The goals of both the fast-paced and the self-paced classes were met by many of the students; in 12–14 months in the Wolfson I class, eight students had completed 4.5 years of mathematics, two students had completed 3.5 years, and six students had completed 2 years (Benbow, Perkins, & Stanley, 1983).

The majority of the fast-paced students continued their mathematics acceleration after the Wolfson class had ended. Very few (approximately 11%) of these students retook any of the classes covered in the Wolfson program, and none retook them all. The vast majority of students moved from the Wolfson classes directly into higher-level mathematics classes; a number of students obtained these classes at local colleges.

The first long-term evaluation of Wolfson I was conducted in 1980, when unaccelerated students were 2 years beyond high school graduation (Benbow et al., 1983). Subjects were divided into four groups for the evaluation. Two of the groups were those in which students had received the treatment (i.e., fast-paced and self-paced). The remaining two groups were used for comparison; one group was composed of qualifying students who dropped the Wolfson class shortly after enrolling and the other group was made up of students who qualified for the class but never enrolled. The follow-up study indicated that students in the Wolfson I class learned mathematics at least as well as students who remained in a traditional school setting. Compared with students who qualified for the class but did not participate, the Wolfson I participants scored equally well on achievement tests in mathematics and better on the Scholastic Aptitude Test at the end of high school.

Further, those students who completed the faster section of the Wolfson class showed the highest level of achievement at age 18. They took more advanced placement (AP) mathematics exams than any other group, and they took those tests at a younger age. They also took more college courses while still in high school, used acceleration opportunities more extensively, and entered college at a younger age than any other group. Despite being accelerated (see Brody & Stanley, in press), they were accepted to and enrolled in more academically challenging colleges and more of them were majoring in mathematics or science than were the members of any other group. A brief evaluation of the Wolfson II class (Benbow et al., 1983) yielded comparable findings. In these evaluations, however, self-paced students were less outstanding than fast-paced students.

*Purpose of Study*

The current paper is a follow-up of Wolfson qualifiers 10 years after the fast-paced classes were offered. It is based on the responses given by these students on a survey that they completed approximately 1 year after college graduation. The primary aspects of the students' experience that were investigated in this study were postsecondary academic achievement and psychosocial factors.

*Academic achievement.* The goal of SMPY in developing the Wolfson classes was to prevent boredom and enhance achievement motivation by offering students an opportunity to accelerate their education, in anticipation that fewer students of exceptional ability would lose interest in mathematics over the years. It was also hoped that the program would increase the probability of its students later enrolling in mathematics and science training programs, thereby enlarging the pool of individuals pursuing careers in mathematical and scientific fields. To investigate the fast-paced classes' fulfillment of such aims, we compared several aspects of academic achievement between participants and nonparticipants.

*Psychosocial factors.* One of the primary psychosocial factors addressed in this study is self-esteem. Self-esteem is viewed as a facilitative factor in the realization of intellectual potential (Bandura, 1986; Feldhusen, 1986). Moreover, development of the drive to excel depends on positive self-esteem (Foster, 1983). Thus, for reasons involving achievement, as well as social and emotional well-being, it would not be desirable for fast-paced classes to significantly decrease scores on measures of self-esteem. On the basis of results from evaluations of other enrichment and acceleration programs (e.g., Richardson & Benbow, 1990), we predicted that any relationship between class attendance and self-esteem would be negligible, but slightly negative.

Self-esteem and self-concepts reflect the outcomes of comparisons with peers (Festinger, 1954). Comparing oneself with peers who are as bright as or brighter than oneself, as would be the case for most Wolfson class participants, is predicted to produce a decrease in self-concept (or possibly a more realistic self-concept). One way to avoid such detrimental impact on self-concept and self-esteem in mathematical and scientific areas is to view these areas as uninteresting and unimportant (i.e., "selective evaluation"; Gibbons & Gerrard, in press; Taylor, Wood, & Lichtman, 1983). Thus, attitudinal data, which are interesting in their own right, may also reveal useful information regarding self-esteem. Therefore, another psychosocial factor considered in this study was attitudes toward mathematics and science.

## METHOD

### *Subjects*

In 1972, a group of 397 potential Wolfson participants were identified through direct referral to SMPY by parents and teachers or through being nominated as "gifted" by principals and teachers in the Baltimore County elementary school system. These students took the Academic Promise Test (APT) and qualified for the class if they scored at the 99th percentile on the numbers (mathematics) subtest and also on one of two other subtests: abstract reasoning or verbal. As a result of this testing, 25 students were invited into the class; 6 more were invited on the basis of teacher recommendations and high scores on other tests. Nineteen students accepted the initial invitation, and 3 were added later. Of these 22 students, 6 either dropped the class or, for academic reasons, were asked to leave before its completion. Thus, the Wolfson I class comprised 16 extremely able and motivated students. The grade level of the Wolfson I participants ranged from completion of 6th grade to accelerated completion of 10th grade. There was also one extremely able 9-year-old.

In 1973, a two-step process was used to select students for the fast-paced Wolfson II math course. First, 953 junior high school students were identified to take the SAT through scoring in the top 2% of the nation on age-appropriate standardized tests of mathematical and verbal reasoning. Those who scored at or above 500 on the mathematics and at or above 400 on the verbal section were eligible to move on to the second step. Of 85 students who qualified on the basis of their SAT scores and were invited to take the Educational Testing Service Cooperative Mathematics Algebra I test, 41 did so. Forty students scored at or above the 48th percentile on this test and were invited to enroll in the fast-paced math class; 31 accepted. Two students were added later. Of these 33 students, 5 either dropped the class or, for academic reasons, were asked to leave before its completion. The 28 highly able participants in this Wolfson II class ranged from seventh graders to accelerated ninth graders. For further details regarding the selection of students for Wolfson I and II, see Fox (1974) and George and Denham (1976).

As in past evaluations, a comparison group was constructed of students who qualified for a Wolfson class but did not participate. This group included students who chose not to enroll in a class and students who dropped out of a class before its completion. Participants were also divided into fast-paced and self-paced groups, but very few differences were found between these two groups at age 23. For this reason, only comparisons between participants and nonparticipants are presented in this paper. Moreover, because past research (Benbow et al., 1983) has revealed that students in Wolfson I and Wolfson II do not differ on the variables relevant to this evaluation, information from members of these two classes was combined for the current study.

Because the SAT was used as a qualifying test for Wolfson II and the range of acceptable scores was large, the possibility that participants scored significantly higher than qualifying nonparticipants needed to be addressed. No significant differences were found on this measure; eighth grade SAT-M scores were 580 for participants and 570 for nonparticipants. The SAT was not used to select students for Wolfson I; participants and nonparticipants alike scored at the 99th percentile on two subtests of the APT.

It should be noted that the design of this study is not truly experimental because of the self-selection of participating students. The performance of a comparison group of qualifying nonparticipants, however, was intended to function as an approximate baseline for talented students. Although there may be differences between the treatment and comparison groups that are not related to Wolfson participation status, the qualifying nonparticipants are likely to be more similar to the participants than are the average students used in the calculation of national norms.

*Procedure*

Because of the longitudinal nature of this study, there were some special difficulties involved in data collection. Twelve of the original subjects (10%) had requested to be dropped from the study, and 11 (9%) could not be located and therefore could not be surveyed. Omitting these 23 students from the subject pool left 98 subjects for whom it was possible to obtain responses. Of these 98 subjects, the 95 who did complete questionnaires provided a response rate of 96.9%. There was no difference in response rate between treatment and comparison subjects.

The treatment group was composed of (a) students who completed the original, fast-paced Wolfson classes and (b) students who dropped into slower, self-paced classes. Each of these two subgroups included both males and females. The comparison group was composed of (a) students who dropped out of a Wolfson class before completing it and (b) students who qualified for a class but never enrolled ($n$ = 50). The number of students in each group is summarized in Table 1.

Table 1
*Number of Male and Female Subjects in Different Treatment and Comparison Groups*

| | Treatment | | Comparison | |
|---|---|---|---|---|
| | Fast-paced | Self-paced | Dropped out | Never enrolled |
| Male | 21 | 5 | 3 | 32 |
| Female | 5 | 6 | 5 | 18 |

*Note.* $n$ = 37 for treatment group; $n$ = 58 for comparison group.

### *Instrumentation*

Students were surveyed via a 24-page printed questionnaire that was mailed to them when they were at the age of 23 (approximately 1 year after college graduation for most students). Most of the survey items were formatted as direct requests (i.e., Please specify your major) or as multiple-choice questions. There were, however, several exceptions.

Astin's (1977) ranking of United States colleges and universities was used to rank-order the undergraduate schools that subjects attended. Similarly, Gourman's (1983) rating of graduate and professional programs was used to rank the graduate departments in which students studied. In both of these systems, lower numbers indicate greater prestige. The number of accelerative methods used by students was determined by counting up the number of items endorsed from a list of possible accelerative methods (e.g., AP examinations and college courses while in high school). Attitudes toward mathematics and science were assessed by items that addressed confidence and interest in mathematics and science (5-point Likert scales), as well as perceived difficulty of math and science (5-point Likert scales) and the usefulness of each of these areas to students' planned careers (4-point Likert scales). Because two of the eight items were on 4-point, rather than 5-point, scales, the maximum possible score on the measure of attitudes toward mathematics and science was 3.75 instead of 4. Self-esteem and locus of control were measured through the use of 12 items (6 per scale) taken, with minor modifications, from the National Longitudinal Study (NLS) questionnaire (Conger, Peng, & Dunteman, 1976; Peng, Fetters, & Kolstad, 1981). These items also used a 5-point Likert response format.

## RESULTS

### *Post-Secondary Academic Achievement*

Ninety-seven percent of the participants and 98% of the nonparticipants attended a four-year college. Colleges attended by more than one student in either group are listed in Table 2. Members of both groups achieved academically at a high level during college (see Table 3). Participants scored higher than did nonparticipants on

Table 2
*Percent of Participants and Nonparticipants Attending Specific Universities*

| College | Participants | Nonparticipants |
|---|---|---|
| Brown University | 0 | 4 |
| Georgetown University | 0 | 4 |
| Harvard University | 6 | 0 |
| Johns Hopkins University | 31 | 9 |
| Massachusetts Institute of Technology | 8 | 0 |
| Princeton University | 6 | 0 |
| Rensselaer Polytechnic Institute | 0 | 4 |
| Towson State University, Maryland | 0 | 4 |
| University of Maryland, Baltimore County | 0 | 5 |
| University of Maryland, College Park | 0 | 12 |
| Virginia Polytechnic and State University | 6 | 4 |
| Western Maryland College | 0 | 4 |

Table 3
*Undergraduate Academic Information for Participants and Nonparticipants*

| | Percent responding | |
|---|---|---|
| | Participants | Nonparticipants |
| Attended college | 97 | 98 |
| Undergraduate math/science majors | 47 | 41 |
| Took elective math courses | 56 | 53 |
| Took elective science courses | 51 | 44 |
| Utilized acceleration | 62 | 55 |
| Earned honors and awards in college | 78 | 67 |
| Received math/science awards up to and including college | 22 | 21 |
| Received non-math/science awards up to and including college | 22 | 19 |
| Entered college early | 25 | 4* |

*Note.* $n = 37$ for participants; $n = 58$ for nonparticipants.
$^{*}p < .05$

all undergraduate achievement variables, but only two statistically significant differences were found between the treatment and comparison groups. Participants attended higher-ranking colleges than did nonparticipants (medians = 13.5 and 158, respectively; $\chi^2$ [1, $N$ = 93] = 6.36, $p < .05$). Also, more participants than nonparticipants entered college before the age of 17 ($\chi^2$ [1, $N$ = 80] = 5.83, $p < .05$). Because of the small sample size, however, this finding must be regarded as tentative.

Achievement was high for both groups at the graduate level, but participants outscored nonparticipants on all individual variables (see Table 4). Participants were significantly more likely to attend graduate school than were nonparticipants ($\chi^2$ [1, $N$ = 87] = 7.28, $p < .01$). This finding held for females (82% vs. 24%; $\chi^2$ [1, $N$ = 32] = 7.65, $p < .01$) but not for males. There were too few females involved, however, for any firm conclusions to be drawn. Graduate schools attended by students from both groups were highly-ranked (median = 9.5 for participants, 19 for nonparticipants).

Areas in which students majored in both undergraduate and graduate school are listed in Tables 5 and 6, respectively. Eleven percent of the participants and 7% of

Table 4
*Graduate Academic Information for Participants and Nonparticipants*

| | Percent responding | |
|---|---|---|
| | Participants | Nonparticipants |
| Attended graduate school | 86 | 56* |
| Created an original invention/process | 19 | 14 |
| Authored published material | 23 | 14 |

*Note.* $n = 37$ for participants; $n = 58$ for nonparticipants.
$*p < .05$

Table 5
*Percent of Participants and Nonparticipants Selecting Specific Undergraduate Majors*

| Major | Participant | Nonparticipants |
|---|---|---|
| Architecture | 3 | 2 |
| Arts | 6 | 9 |
| Biology | 6 | 11 |
| Business | 3 | 5 |
| Communications | 3 | 0 |
| Computer Science | 6 | 14 |
| Education | 0 | 2 |
| Engineering | 34 | 13 |
| English/Literature | 0 | 4 |
| Languages | 3 | 0 |
| Health-related fields | 3 | 4 |
| Mathematics | 11 | 7 |
| Philosophy/Religion | 3 | 2 |
| Physical Sciences | 3 | 5 |
| Social Sciences | 11 | 14 |
| Other/Undecided | 6 | 9 |

*Note.* $n = 36$ for participants; $n = 57$ for nonparticipants.

Table 6
*Percent of Participants and Nonparticipants Selecting Specific Graduate Majors*

| Major | Participant | Nonparticipant |
|---|---|---|
| Applied math; engineering; computer science | 50 | 28 |
| Architecture | 3 | 0 |
| Arts | 0 | 7 |
| Business administration | 10 | 4 |
| Education | 3 | 0 |
| Environment | 3 | 0 |
| Humanities | 3 | 7 |
| Law | 10 | 28 |
| Medicine | 13 | 17 |
| Physical science | 3 | 4 |
| Social science | 0 | 7 |
| Unreported | 9 | 9 |

*Note.* $n = 32$ for participants; $n = 33$ for nonparticipants.

the nonparticipants majored in mathematics as undergraduates; this difference was nonsignificant. No students from either group concentrated in pure mathematics in graduate school. Of the participants who attended graduate school, however, 50% concentrated in applied mathematical fields. Although fewer nonparticipants (28%) concentrated in applied mathematics in graduate school, the difference was not statistically significant.

### *Psychosocial Factors*

An attempt was made in this study to measure locus of control, but the scale used proved to be unreliable for this sample (Cronbach's alpha = .34). The data, therefore, were discarded. The measure of self-esteem, however, was sufficiently reliable to be used in this investigation (alpha = .75). The mean level of self-esteem at which nonparticipants ranked themselves, on a scale from 1 to 4, was significantly higher than that of participants (means = 3.34 and 3.05, respectively; $t(84) = 2.53, p < .05$).

There was no difference between treatment and comparison subjects in attitude toward mathematics and science. Both groups expressed positive attitudes, each scoring 2.7 on a Likert scale ranging from 0 to 3.75.

## DISCUSSION

### *Postsecondary Academic Achievement*

Both the participants and the nonparticipants performed very well academically at all levels. Both groups accelerated their education. At the undergraduate level, members of both groups took more mathematics and science courses than their schools required, and members of both groups earned awards and honors for their academic work. The majority of students from each group attended graduate school; the departments in which they studied were prestigious. Thus, it appears that both treatment and comparison group members were high in ability and achievement motivation. In all academic variables studied, however, the treatment group scored higher, although not necessarily significantly so.

Despite the strong performance of both groups, the participants attended significantly higher-ranking colleges than did the nonparticipants. (Note: SMPY did not provide any special assistance to Wolfson students in college application or admission.) The difference between the groups in college rank cannot be attributed solely to fast-class participation, however, since there are a number of potentially confounding factors at work. For example, students who were motivated to complete a Wolfson class may also have been motivated to seek out challenging colleges. Nevertheless, this finding can be seen as a positive outcome of class participation. The reputation of a school reflects, in part, its ability to provide quality learning experiences for students. Therefore, by attending prestigious colleges, participants are likely to increase their opportunities to achieve highly. This enhancement of achievement opportunities illustrates the multiplicative effect of advantage (Zuckerman, 1977); early opportunities for achievement, in this case the fast-paced math class, often lead to other such opportunities later in life.

Participants were also more likely to attend graduate school than were nonparticipants. This finding was due to differences among females, not males. There are several possible explanations for this finding. It is possible that girls who chose to attend a Wolfson class are more highly motivated academically than those who chose not to participate in this fast-paced mathematics program. Effects of class participation, however, also may have influenced graduate school attendance. The encouragement and training received by the girls who took a fast-paced mathematics class may have helped them continue to strive toward academic goals. The class also may have helped the female participants to overcome sex-role stereotyping of mathematics as an activity appropriate for males rather than females. Such stereotyping may negatively influence the achievement of females (Benbow, 1988; Benbow & Stanley, 1982; Eccles, 1985; Fox, 1976; Huston, 1983; Ruble, 1988).

The finding that few students majored in math at the undergraduate level and no students concentrated in mathematics at the graduate level is not surprising; very few students, under any conditions, elect to study pure mathematics (National Science Board, 1988). Nonetheless, the development of mathematical skills is necessary to participation and productivity in many related areas. It is apparent, from the number of participants who attended graduate school in areas of applied mathematics, that the fast-paced classes did provide students with an understanding of mathematics that was sufficient for advanced study in mathematics-related fields. They also may have increased the rate at which talented students entered applied mathematics, although the finding in this regard, due to small sample size, was not statistically significant.

### *Psychosocial Factors*

As predicted, our results indicated that nonparticipants demonstrated higher self-esteem than did participants at age 23. Although we do not know what the students' self-esteem scores were before their participation in the Wolfson classes, studies of other acceleration or enrichment programs designed for gifted students have also reported lower self-esteem scores among participants than among nonparticipants (Coleman & Fults, 1982; Richardson & Benbow, 1990). In the case of the Wolfson classes, this difference in self-esteem could be related not only to the high-ability social comparison group to which participants were exposed during the Wolfson class, but also to high-ability social comparison groups they encountered later in their lives. For example, Wolfson participants attended colleges of higher rank than did nonparticipants. Therefore, it is possible that the participants continued to compare themselves with others more highly able long after the Wolfson classes had ended. The magnitude of the observed difference was small, however, and the average self-esteem score in each group was positive. These findings indicate that fast-paced classes may not place students at any serious psychosocial risk. In fact, it has been argued that the slight decrease in self-esteem may actually be beneficial because it indicates that self-esteem has become more realistic (e.g., Robinson & Noble, 1991).

Also, no differences were found between participants and nonparticipants in attitudes toward mathematics and science. Therefore, it appears that even if there was a decrease in self-esteem following enrollment in a Wolfson class, students were able to cope with it without using selective evaluation (i.e., without resorting to derogating mathematics-related fields). Alternatively, this finding may indicate that the decrease in self-esteem was negligible.

*Limitations and Summary*

The longitudinal nature of the current data is a unique feature of this study. It allows us to consider possible associations between fast-paced class participation and both academic achievement and psychosocial adjustment long after the completion of the classes themselves. Because of the self-selection of students to the participant and nonparticipant groups, cause and effect cannot be established (Scarr, 1985). There may be alternate explanations of the overall differences between the treatment and comparison groups that have nothing to do with the fast-paced classes (e.g., in initial motivation). Also, the small sample size involved in this study made it difficult to establish statistically significant differences. Nevertheless, the current work suggests possible relationships that are worthy of further investigation.

Keeping in mind the limitations inherent in the design of this study, we can draw several tentative conclusions. More fast-paced mathematics class participants than nonparticipants entered undergraduate school before the age of 17. Participants attended higher-ranking colleges than did nonparticipants. Among females, participants pursued more advanced educational training than did nonparticipants. Moreover, on all variables measuring achievement during the undergraduate and graduate years, the participants scored better than the nonparticipants, although not significantly so. These results suggest that educational interventions may enhance educational achievements and aspirations among gifted students (Benbow & Arjmand, 1990; Benbow, Arjmand, & Walberg, 1991). The Wolfson classes did not harm students in any of the areas studied. The use of fast-paced classes to meet the educational needs of highly intellectually talented children is, therefore, justified on the basis of the findings from this study. Such classes appear to compose one example of the types of programs that "'start' the individual toward the development of talented performance from talent potential" (Passow, 1989, p. 225).

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