

### *Advanced Placement Courses*

As described by the College Board, their Advanced Placement (AP) program gives students the opportunity to take college-level courses and exams while they are still in high school (College Board, 2001a). The courses are intended to help students develop skills and study habits that will be vital in college. Calculus AB covers differential and integral calculus topics that are typically included in an introductory Calculus 1 college course. Calculus BC covers the Calculus AB topics as well as additional topics in differential and integral calculus, and series. The Calculus BC topics are typically included in a two-semester sequence (Calculus 1 and 2) at the college level. AP Statistics covers topics typically included in a one-semester introductory non-calculus-based college course in statistics.

#### *AP Course Enrollment*

Table 1 reports the number of students by grade level who completed an AP mathematics course each school year, from 1990-91 through 2000-01. Only students who received a passing grade are counted in the Table.

In 1997-98 Suburban High School adopted a semestered block schedule at all grade levels. In that year an elective one-semester AP Statistics course was added to the curriculum. Also, Calculus AB and Calculus BC had previously been offered as separate year-long courses under a traditional schedule. The two year-long calculus courses were replaced by a pair of sequential one-semester courses. Thus, students who wished to enroll in Calculus BC did so after completing a one-semester Calculus AB course. In Table 31, students who completed only the one-semester Calculus AB course are counted as having completed “Calculus AB”, while to avoid double counting students who

completed Calculus AB followed by Calculus BC are counted as having completed “Calculus BC” but not “Calculus AB”. Between 1997-98 and 2000-01 a total of 38 students completed both AP calculus and AP statistics, frequently enrolling in the statistics course the year after completing calculus. For these students, both their AP statistics course and their highest level of AP calculus course are reflected in the Table.

Usually, students who enrolled in an AP mathematics courses were in eleventh or twelfth grade. In 1997-98 and 1998-99 eleventh and twelfth graders at Suburban High School had experienced a hybrid schedule: traditional in their early years of high school, and a semestered block schedule nearer the end of their high school career. In Table 1, entries for the two “hybrid-schedule” years are italicized. In the hybrid-schedule years, the total number of students enrolling in AP classes increased over what had been the

*Table 1. Advanced Placement Mathematics Course Enrollment by School Year and Grade Level*

School Year			Grade Level			Total
			10	11	12	
1990-91	Course	Calculus AB AP	-	-	26	26
		Calculus BC AP	-	-	13	13
		Statistics AP	-	-	-	*
	Total		-	-	39	39
1991-92	Course	Calculus AB AP	-	-	30	30
		Calculus BC AP	-	1	8	9
		Statistics AP	-	-	-	*
	Total		-	1	38	39
1992-93	Course	Calculus AB AP	-	1	26	26
		Calculus BC AP	-	-	11	11
		Statistics AP	-	-	-	*
	Total		-	1	37	38
1993-94	Course	Calculus AB AP	-	-	34	34
		Calculus BC AP	-	-	-	**
		Statistics AP	-	-	-	*
	Total		-	-	34	34
1994-95	Course	Calculus AB AP	-	-	30	30
		Calculus BC AP	-	1	10	11
		Statistics AP	-	-	-	*
	Total		-	-	-	-

	<b>Total</b>		-	1	40	41
1995-96	Course	Calculus AB AP	-	-	37	37
		Calculus BC AP	-	-	-	***
		Statistics AP	-	-	-	*
	<b>Total</b>		-	-	37	37
1996-97	Course	Calculus AB AP	-	1	22	23
		Calculus BC AP	-	1	12	13
		Statistics AP	-	-	-	*
	<b>Total</b>		-	2	34	36
1997-98	Course	<i>Calculus AB AP</i>	-	2	16	18
		<i>Calculus BC AP</i>	-	1	9	10
		<i>Statistics AP</i>	-	1	15	16
	<b>Total</b>		-	4	40	44
1998-99	Course	<i>Calculus AB AP</i>	-	2	10	12
		<i>Calculus BC AP</i>	1	8	10	19
		<i>Statistics AP</i>	1	4	15	20
	<b>Total</b>		2	14	35	51
1999-00	Course	<b><i>Calculus AB AP</i></b>	<b>1</b>	<b>1</b>	<b>17</b>	<b>19</b>
		<b><i>Calculus BC AP</i></b>	<b>-</b>	<b>13</b>	<b>3</b>	<b>16</b>
		<b><i>Statistics AP</i></b>	<b>1</b>	<b>3</b>	<b>48</b>	<b>52</b>
	<b>Total</b>		<b>2</b>	<b>17</b>	<b>39</b>	<b>87</b>
2000-01	Course	<b><i>Calculus AB AP</i></b>	<b>-</b>	<b>5</b>	<b>12</b>	<b>17</b>
		<b><i>Calculus BC AP</i></b>	<b>-</b>	<b>15</b>	<b>7</b>	<b>22</b>
		<b><i>Statistics AP</i></b>	<b>-</b>	<b>5</b>	<b>36</b>	<b>41</b>
	<b>Total</b>		<b>-</b>	<b>25</b>	<b>55</b>	<b>80</b>

\* Advanced Placement Statistics was not offered until 1997-98.

\*\* In 1993-94 student transcripts did not differentiate between Calculus AB and Calculus BC.

\*\*\* In 1995-96 too few students enrolled in Calculus BC for the course to be offered.

case previously. A close look at Table 1 indicates that the increase was due to students enrolling in the new AP statistics course. During the hybrid-schedule years, the number of students enrolling in calculus decreased over what had been the case previously. Of those students who studied calculus, a larger percentage completed the two-semester AB/BC sequence than had previously enrolled in the year-long BC course. Another change during the hybrid-schedule years was an increase in the number of eleventh graders enrolling in AP classes.

Beginning in 1999-2000, all Suburban High School students had used a semestered block schedule throughout high school. This was true because seniors that year had been in ninth grade in 1996-97, when the block schedule was piloted with the ninth-grade class. In Table 1, entries for the two “fully block scheduled” years are marked in bold italicized print.

During the fully block scheduled years the number of students enrolling in calculus courses returned to between 35 and 40 students, the level of enrollment that had been typical of the years before the hybrid schedule. The shift towards a larger percentage of calculus students completing Calculus BC continued. In 2000-01 more students completed Calculus BC than had been the case in any previous year.

Meanwhile, a large number of students continued to enroll in the AP statistics class. This led to the total number of students enrolled in AP courses being approximately double what they had been in the years when Suburban High School used a traditional schedule.

It should be noted that, while enrollment at Suburban High School increased slightly at about the time the block schedule was adopted, this change cannot account for the increased enrollment in AP mathematics courses. Between the spring of 1991 and the spring of 1997, the number of students enrolled in AP mathematics divided by the number of students in the senior class generally ranged from .15 to .16. In contrast, in the

spring of 1998 the ratio was .19, in the spring of 1999 the ratio was .23, in the spring of 2000 the ratio was .33, and in the spring of 2001 the ratio was .30.

As noted previously, during the block schedule years there were 38 students who completed both AP calculus and AP statistics. Table 1 records each of these course enrollments as a separate entry adding to the “total” course enrollment reported. However, even when the enrollment is recalculated to count each student who enrolled in an AP mathematics course only once, regardless of the number of courses in which the student enrolled, the number of students enrolled in AP courses divided by the size of the senior class increased after the semestered block schedule and IMP curriculum were implemented. In the pre-block schedule years the recalculation left the number of students enrolled in AP courses divided by the number of students in the senior class unchanged, at between .15 and .16. In the spring of 1998 the recalculated ratio was .16, in the spring of 1999 the recalculated ratio was .19, in the spring of 2000 the recalculated ratio was .27, and in the spring of 2001 the recalculated ratio was .28.

#### *AP Exam Grades*

For a fee, students who have completed an AP course can take an exam administered by the College Board. The exams are graded on the following scale:

- 5: extremely well qualified
- 4: well qualified
- 3: qualified
- 2: possibly qualified
- 1: no recommendation

The College Board sets its grading scale so that the lowest grade of 5 is equivalent

to the average score earned by college students receiving grades of A in college, the lowest grade of 4 is equivalent to the average B, and the lowest grade of 3 is equivalent to the average grade of C. In general, a score of 3 or higher on an AP exam indicates sufficient mastery of course content to allow exemption from a college course, credit, or both. Research has found that when students with AP grades of 3 or better are placed out of introductory college courses, they are more likely to receive grades of A or B in the sequent higher level courses than are those non-AP students who took the introductory course before the higher-level course (College Board, 2001b).

Table 2 reports AP exam grades received by students at Suburban High School each year from 1994-95 through 2000-01. In 1994-95 and 1995-96 Suburban High School paid the fee for AP exams, and required all students enrolled in AP courses to take the exam. In 1994-95 two students who received a course grade lower than a “C” completed the AP exam, so the number of exam takers that year is actually higher than the number successfully completing the course. Key informants at the school weren’t certain of the dates, but believed that the requirement to take the exam was discontinued in 1996-97 and the fee payment was discontinued in 1997-98. For this reason, in 1996-97 and thereafter the number of students taking each exam was noticeably smaller than the number of students successfully completing the corresponding course. It should also be noted that under the semestered block schedule Suburban High School offered Advanced Placement Calculus AB only during the fall semester, while the Advanced Placement exam was not administered until the following May. The current calculus

*Table 2. Advanced Placement Exam Grades by School Year and AP Mathematics Course*

School Year	Exam Grade	Total
-------------	------------	-------

			5	4	3	2	1	(exams completed/ # students completing course)
1994-95	Course	Calculus AB AP	6	15	8	3	1	33/30
		Calculus BC AP	4	2	3	1	-	10/11
		Statistics AP	-	-	-	-	-	*
	<b>Total</b>		10	17	11	4	1	43/41
1995-96	Course	Calculus AB AP	5	11	13	2	3	36/37
		Calculus BC AP	-	-	-	-	-	**
		Statistics AP	-	-	-	-	-	*
	<b>Total</b>		5	11	13	4	3	36/37
1996-97	Course	Calculus AB AP	6	7	2	3	-	18/23
		Calculus BC AP	1	7	3	1	1	13/13
		Statistics AP	-	-	-	-	-	*
	<b>Total</b>		7	14	5	4	1	31/36
<i>1997-98</i>	<i>Course</i>	<i>Calculus AB AP</i>	<i>1</i>	<i>7</i>	<i>2</i>	<i>1</i>	<i>-</i>	<i>11/18</i>
		<i>Calculus BC AP</i>	<i>-</i>	<i>2</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>2/10</i>
		<i>Statistics AP</i>	<i>2</i>	<i>4</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>6/16</i>
	<b>Total</b>		<b>3</b>	<b>13</b>	<b>2</b>	<b>1</b>	<b>-</b>	<b>19/44</b>
<i>1998-99</i>	<i>Course</i>	<i>Calculus AB AP</i>	<i>4</i>	<i>6</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>10/12</i>
		<i>Calculus BC AP</i>	<i>6</i>	<i>1</i>	<i>2</i>	<i>1</i>	<i>-</i>	<i>10/19</i>
		<i>Statistics AP</i>	<i>3</i>	<i>3</i>	<i>-</i>	<i>1</i>	<i>-</i>	<i>7/20</i>
	<b>Total</b>		<b>13</b>	<b>10</b>	<b>2</b>	<b>2</b>	<b>-</b>	<b>27/51</b>
<b>1999-00</b>	<b>Course</b>	<b>Calculus AB AP</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>5/19</b>
		<b>Calculus BC AP</b>	<b>12</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>14/16</b>
		<b>Statistics AP</b>	<b>9</b>	<b>6</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>15/52</b>
	<b>Total</b>		<b>23</b>	<b>10</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>34/87</b>
<b>2000-01</b>	<b>Course</b>	<b>Calculus AB AP</b>	<b>5</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>6/17</b>
		<b>Calculus BC AP</b>	<b>18</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>20/22</b>
		<b>Statistics AP</b>	<b>10</b>	<b>8</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>20/41</b>
	<b>Total</b>		<b>33</b>	<b>10</b>	<b>3</b>	<b>-</b>	<b>-</b>	<b>46/80</b>

\* Advanced Placement Statistics was not offered until 1997-98..

\*\* In 1995-96 too few students enrolled in Calculus BC for the course to be offered.

teacher at Suburban High School commented that she was concerned that this long delay discouraged a number of students who would otherwise have done so from completing the AB exam.

Table 2 uses the same print convention as Table 1, marking hybrid-schedule cohorts in italicized print and cohorts using a block schedule throughout high school in bold italicized print. The first thing to notice about Table 2 is that although the number of students enrolled in AP courses had increased under the hybrid block schedule (school years 1997-98 and 1998-99) the number of students who went on to take the

exam actually decreased in those years. The number of students taking the tests recovered in 1999-00, and grew to the highest level it had ever been in 2000-01—higher even than in the years when the school paid for the exam and required all students in AP courses to take them.

School year 1999-00 was different from preceding years in two ways that are relevant to the focus of this study. First, 1999-00 was the first year that all students at had been enrolled in a semestered block schedule throughout their years at Suburban High School. Second, a substantial number of the students enrolled in AP courses had utilized IMP as their core curriculum. This is because a number of eleventh graders were enrolled in AP courses, all of whom had used IMP in earlier years. Among twelfth graders that year most students in the Honors program had begun their study of high school mathematics with Algebra 1 in eighth grade and had completed the traditional curriculum in high school.

In school year 2000-01, like the previous year, all students had used a semestered block schedule every year they attended Suburban High School. In addition, except for transfer students all students enrolled in AP courses that year had utilized IMP as their core high school curriculum.

The second thing to notice about Table 2 is the overall improvement in student test scores during the last two years reported in the table, as reflected in the increased number of students receiving a score of “4” or “5” on the exam. These were the two years when the block schedule was fully implemented, and when students taking the AP tests had utilized the IMP curriculum.

The improved performance on AP exams is particularly evident if one focuses on



the most advanced mathematics course offered at Suburban High School: Calculus BC. To make this pattern more evident, Table 3 displays only the Calculus BC AP exam scores.

The Table shows a marked increase in the number of students taking the exam during 1999-00 and 2000-01 and in student exam grades during those years. The improvement in exam grades is larger than can be explained by chance. A logistic regression analysis comparing in the two fully-block-scheduled years (1999-00 and 2000-01) scores to those of the two hybrid-block-scheduled years (1997-98 and 1998-99) yielded a Wald Chi-square statistic of 8.029 with 1 degree of freedom,  $p=.005$ . A logistic regression analysis comparing the two fully-block-scheduled years to 1996-97, the only traditionally-scheduled year in the table during which students in Advanced Placement Calculus BC had the option of skipping the exam, yielded a Wald Chi-square statistic of 16.3 with 1 degree of freedom,  $p<.0005$ .

*Table 3. Advanced Placement Calculus BC Exam Grades by School Year*

School Year	Exam Grade					Total
	5	4	3	2	1	
1994-95 (Traditional Schedule. Traditional Curriculum.)	4	2	3	1	-	10
1995-96 (Traditional Schedule. Traditional Curriculum.)	-	-	-	-	-	*
1996-97 (Traditional Schedule. Traditional Curriculum.)	1	7	3	1	1	13
1997-98 (Hybrid schedule. Traditional Curriculum.)	-	2	-	-	-	2
1998-99 (Hybrid schedule. Traditional Curriculum.)	6	1	2	1	-	10
<b>1999-00 (Block schedule. Mostly IMP)</b>	<b>12</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>14</b>
<b>2000-01 (Block schedule. All IMP.)</b>	<b>18</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>20</b>

Although the previous paragraph labeled 1999-00 and 2000-01 as “fully block scheduled” years, it should be noted that during the two previous “hybrid” years the Calculus BC course had been offered in a two-semester format, just as it was in 1999-00 and 2000-01. A key difference between the years that did so well and the two preceding years is that every Calculus BC student in 2000-01 had used the IMP curriculum, and 13 of the 16 students enrolled in Calculus BC during 1999-00 had used the IMP curriculum. This was the case in 1999-00 because under the semestered block schedule a number of students tended to enroll in Calculus during their junior year. Of the 13 eleventh graders taking Calculus BC in 1999-2000, 12 had previously taken IMP courses. In addition, one of the three twelfth graders taking Calculus BC in 1999-2000 had taken the core IMP sequence. Prior to 1999-00, the only student enrolled in Calculus BC who had utilized the IMP curriculum at Suburban High School was an extremely gifted student who took calculus in tenth grade during 1998-99.

Focusing on the 2000-01 school year, which was the first year in which all students at Suburban High School had used both the IMP curriculum and a semestered block schedule, achievement on the Calculus BC exam was truly impressive. Twenty students took the exam; eighteen received a grade of 5 and the remaining two received a grade of 4, for an average grade of 4.9. To put this in perspective, in 2000-01 there were only eight public schools in the United States where at least 20 students took the Calculus BC exam and the mean grade was 4.9 or better (personal communication, College Board, April 25, 2002).