nodifications to the joints since 1984, told *cience* that "I was convinced that yes, it's dequate, that we were in good shape—but nly so long as there were no adverse launch onditions, such as severe bending, unusual old, or sloppy workmanship."

The tragedy is that at least one and possily all three of these factors may have played role in the disaster. Last November, workrs at the launch site employed by the ockheed Corporation damaged a segment f one of the boosters destined for the 28 anuary launch, requiring its replacement. n internal agency review concluded that vorker inexperience, lack of motivation, and aulty equipment were to blame. Subseuently, a similar segment on the other ooster was replaced, at the last moment efore the Challenger was transported to the ad, in an effort to ensure thrust equilibrium luring launch. According to sources at NASA and a member of the White House ommission, the errant plume erupted from he side of the booster in the vicinity of a ole drilled in this segment to test for leaks mmediately after its installation. At the time *Science* went to press, NASA was said to be investigating the possibility that workers carelessly forgot to plug this hole, thereby allowing flames which penetrated the first gasket to breach the booster wall.

A related hypothesis is that an unusually low temperature of 38°F on the launch pad at the time of launch made the first gasket so stiff that it failed to seat properly and seal the joint. According to several Thiokol officials, no reliable data are available on the performance of the gaskets in the boosters below 51°F, the ambient temperature on the pad at the coldest previous launch, in January 1985. One gasket was badly eroded during that launch, and a backup was charred. Much less erosion occurred on a flight in October, when the ambient temperature was 84°. According to one engineer, "What little information we had in [the 45° to 50°] region indicated that the resiliency of those [gaskets] was going to hell in a handbasket, that they would essentially lie dormant at such temperatures, like a sleeping bear, with no power to think. The trend was pretty clear."

NASA's Larry Mulloy has stated publicly that the decision to launch was ultimately based on an "analysis" showing that "should we compromise the primary ring, the secondary would seat as it has done in the past, even under those temperature conditions." He declined repeated requests from *Science* for amplification. Budget analyst Richard Cook, who has now moved to the Treasury Department, points out the incongruity of such a decision, given that the agency had earlier declared that the gasket system could not be considered fully redundant.

Perhaps the greatest irony is that some potential solutions to the joint problem, including a new putty, a larger gasket, and a seal stiffener, were to be tested at Morton Thiokol on 13 February. The test, which will cost $15 million, has now been postponed until the accident investigation is completed. NASA's Michael Weeks says that this experiment should probably have been performed earlier. "We should have made more effort earlier, of course," he says, adding that hindsight makes this an easy judgment. ■ R. JEFFREY SMITH

Education Makes Comeback at NSF

After being abolished when Reagan came to office, the education directorate now has a steady budget and is gaining credibility among its critics and within the foundation

PRESIDENT Reagan's proposed budget for next year gives the National Science Foundation's science education rogram $89 million, a $2-million increase ver the current year. Considering the preailing pressures for deficit reduction and he ups and downs of the program in recent ears, science education seems at least to be ack from the fiscal depths to which it sank n the early 1980's.

The Reagan Administration abolished NSF's science education directorate upon aking office in 1981. But the decision was eversed in October 1983, following a wave f public concern about the state of Ameran schools. Although federal funding for nprovement of science and math education as not increased spectacularly in the 3 years ince NSF's role in science education was estored, the current view among NSF watchers is that the directorate has now won acceptance by its critics in the Administration—and perhaps inside the foundation as well.

The major initiative by the Directorate for Science and Engineering Education since its rebirth has been in precollege education. A total of $47.7 million is in the new budget for precollege activities. Of that, $22.7 million would go to materials development and research and $25 million to teacher enhancement, the same as for the current year.

Revival of the precollege program has proceeded with some delay and financial backing and filling. The directorate's top job of NSF assistant director for science and engineering education went unfilled for about 8 months until the appointment of Bassam Z. Shakhashiri, who assumed the post in mid-1984. A University of Wisconsin chemistry professor with substantial experience in science education, Shakhashiri was faced with rebuilding the directorate staff and developing a new strategy for science and engineering education for the foundation.

During the period when the directorate was gearing up, Congress appropriated more money for precollege activities than the NSF spent. Some $31.5 million remained unexpended at the end of fiscal year 1984, and these funds were carried over to the next fiscal year. With the $82 million appropriated for the education directorate in fiscal year 1985, a total of $113 million appeared to be available. Early last year, however, with pressures building on all parties to restrain expenditures, discussions between the Office of Management and Budget and foundation officials led to a decision to defer spending of the $31.5 million to the 1986 fiscal year. Although the bookkeeping is confusing, the education directorate ended up with a budget of only $87 million for 1986. The "deferred" money was actually absorbed by the NSF research directorates and lost to the education program.

The shift was made with the direct agreement of the congressional committees involved, although the House Appropriations Committee noted in its report that it was going along reluctantly. Interested outsiders tended to see the episode as illustrating the fragility of the directorate's political base,

even within NSF. Education has traditionally been regarded as something of an interloper in the foundation, where the basic research directorates have always dominated the power structure.

The credibility of the directorate within the foundation may, however, have been enhanced by, among other things, the formation of an advisory committee consisting of some two dozen people, a number with strong research credentials. The chairman is Berkeley chemist George C. Pimentel.

Another problem of the born-again science education directorate has been to lay out policies that will satisfy both its clients and its critics. In the directorate's former life, the precollege program was the most politically sensitive activity (*Science*, 14 December 1984, p. 1291). In the 1970's, NSF had run-ins with Congress over aspects of the science education program, particularly its curriculum development projects for schools, and care has obviously been taken not to rattle any skeletons in the closet.

Shakhashiri, who accents the positive and steers clear of recriminations on or off the record, notes that the precollege program has been up and running effectively for a year. The full amounts of grant funds available were expended in both the materials and research and the teacher enhancement portions of the program for fiscal year 1985, which ran through the end of September. Shakhashiri adds that the directorate is en route to spending the full $47.7 million available in the current year for the precollege program.

According to Shakhashiri, the directorate has been successful in its aim of striking a balance between projects for instructional materials for high schools on the one hand, and for elementary and middle schools on the other. In its earlier incarnation, the education directorate put heaviest emphasis on high school course improvement in science and math. Shakhashiri says that a good early grounding in science and math is essential to give students the interest and knowledge to pursue the subjects later. Nearly half the projects funded so far are for elementary and middle school materials.

In the Washington education community and on Capitol Hill the attitude appears to be one of at least provisional approval of the way the directorate is working. The only score on which the directorate's congressional patrons have consistently demonstrated some testiness is that of long-range planning. The NSF authorization bill this year had written into it a requirement that the foundation develop a 5-year strategic plan on science and engineering education; the first to be submitted on 30 November and updated every year.

While Shakhashiri and his colleagues have been mainly concerned with getting precollege activities going, another major effort may be on the horizon. The National Science Board has had a committee on undergraduate science and engineering education pondering the subject since last May. It is scheduled to report in March and to offer recommendations that could add a new component to the directorate's operations.

The directorate's current program concentrates on precollege and graduate education. The NSF graduate fellowship program—funded at $27.3 million in the new budget—is one of the longest running federal education programs, having started in 1952 and survived on a reduced scale even when the directorate was in eclipse. The foundation's only program that benefits undergraduate education is a college instrumentation program that is scheduled for a $2-million increase to $7.5 million in the new budget.

Bassam Shakhashiri

Education chief accentuates the positive.

Shakhashiri suggests that an initiative in undergraduate education would open the way to greater involvement of the directorate in engineering education. The problem would be to find money for a new start.

The federal response is also conditioned by the Administration's view that public education is primarily the responsibility of the states and localities and that the federal role should be sharply circumscribed. Secretary of Education William J. Bennett played on this theme at his department's briefing on the 1987 budget when he said, "as a result of the improved economy and the national focus on education, both brought about by our Administration, states and localities have decided to increase their education spending in recent years—and are continuing to do so. I expect that these increases will more than offset the reductions we are proposing." (The President requested $15.2 billion for the Department of Education for next year compared to the $18.4 billion appropriated for this year.)

The Department of Education has sharply limited its support of science and math programs in the schools. An education bill passed in 1984 (PL 98–377) was aimed mainly at improving science and math instruction with programs funded through both NSF and the Department of Education. The bill had a face value of $1 billion to be spent in fiscal years 1984 and 1985. No funds were provided in 1984, however, and only $100 million was voted in 1985. For the current year, some $54.5 million was provided through the Department of Education for improvement of science and math instruction, most of it in the form of block grants to the states. Under the President's new budget, the Department of Education would end the science and math grant program and shift the funds to a new program open to teachers and administrators in all disciplines. This would require passage of new legislation to be funded at $75 million.

The first half of the decade has unquestionably been a period of unusual activity in education reform at the state and local level. Although patterns varied greatly, academic requirements were raised in many states, competence examinations for teachers were imposed, and efforts made to improve teacher quality, for example, by instituting merit pay provisions or providing salary differentials for teachers in shortage categories like science and math.

At the state and local levels, the most active phase of the drive for educational reform appears to be ending. The campaigns mounted to attain financial and legislative goals are mostly over and the tendency is to review what has been accomplished and to implement the changes.

In Washington, the mood also seems to be one of reassessment. The problems that provided so much grist for the cautionary reports on education of a few years ago have not been solved. But education is one of the areas where disagreement about the federal role has produced something of a standoff between the Administration and Congress. Where there does appear to be consensus is that for the foreseeable future federal initiatives in education, including NSF's in science, math, and engineering, will have to operate with decidedly limited resources. ■ JOHN WALSH