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The Eroding Standards Issue: A Case Study from the University of Waterloo

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ABSTRACT

The proposition is addressed that the mathematical skills of first year entrants into the Faculties of Mathematics, Engineering, Science and Applied Health Sciences at The University of Waterloo have declined. Analysis of a series of scores from a mathematics diagnostic test for new students suggests a decline over the period 1991–93 and possibly through to 1995. This reproduces a trend detected at The University of Western Ontario. By the mid-1990s, however, the scores level out. Many of the faculty members questioned in a survey also perceived a decline, and, independently of the time series data, informants pointed to the early 1990s as the critical period of decline. The feeling of being under pressure to adjust to declining standards by upward "belling" of grades varied greatly by faculty, being far more prevalent within the Faculty of Mathematics than in other faculties surveyed. The survey respondents claimed that most deficiencies in mathematics preparation in the high schools were remediable by working to alter the attitudes and expectations of first year university students.

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RÉSUMÉ

Cet article révéle une baisse du niveau de connaissances en mathématiques des étudiants de première année des Facultés de mathématiques, ingéniérie, sciences et sciences appliquées de la santé à l'Université de Waterloo. L'analyse d'une série de notes issue d'un test diagnostique en mathématiques destiné aux nouveaux étudiants semble indiquer un déclin portant sur la période 1991–93, voire jusqu'en 1995. C'est la reproduction d'une tendance détectée à l'University of Western Ontario. Toutefois, au milieu des années 90, les notes se nivélent. Bon nombre de membres des facultés sondées ont également perçu un déclin et, indépendamment des données chronologiques, ils situent le début des années 90 comme la période critique du déclin. La pression liée à la nécessité de s'adapter au niveau de connaissances à la baisse en gonflant les notes a varié de façon importante d'une faculté à l'autre et a été beaucoup plus fortement ressentie dans celle de math matiques que dans les autres facultés interrogées. Les personnes sondées déclarent qu'il est possible de remédier à la plupart des lacunes dans la préparation des mathématiques au collège en s'appliquant modifier les attitudes et les attentes des étudiants en première année à l'université.

> *When to the sessions of sweet silent thought I summon up remembrance of things past* (Shakespeare, Sonnet 30)

INTRODUCTION

Concern about decline in standards for secondary and postsecondary students in Canada has been expressed at least as far back as Hilda Neatby's (1953) *So Little for the Mind,* nearly a half century ago. This early work complained of "this 'age without standards' " (p. 1) corrupted by the "progressive education" movement dating back to the turn of the century. It is a theme repeated many times since and never more emphatically than in recent times.

In the 1970s, the Association of Universities and Colleges of Canada (AUCC) released a report addressing enrollment and quality issues. The report (Barbeau, Bruce, Clake, et al., 1997) stated:

> Whatever the reason, there is no doubt that large numbers of first year students have difficulty in writing essays, in expressing themselves coherently, and in manipulating mathematical symbols and expressions. (p. 20).

The AUCC report was motivated largely by the ending of provincial level high school leaving examinations in the 1960s and early 70s, but in 1984 a more fundamental critique appeared with *The Great Brain Robbery: Canada's Universities On The Road To Ruin* (Bercuson, Bothwell, & Granatstein, 1984). The authors pointed precisely to the accessibility and expansion of universities in the 1960s and early 70s as the reasons for declining academic standards:

> Canadian universities no longer take only the best students and no longer give their students the best education. The value, if not the very meaning, of a university degree has been steadily eroded. (Bercuson, et al., 1984, p. 7)

It was a later book by the same authors (Bercuson, et al., 1997) that provoked a counter-interpretation. Michiel Horn, an historian at York University, presented an alternative view of Ontario universities in his October 1997 *Globe and Mail* article, "The Myth of a Golden Age in Higher Education." Horn dismissed much discussion on higher education as romanticizing of the past, asserting that few delusions are more widespread than a belief in a lost golden age. He contended:

> Unhappy with what, as we age, we take to be evidence of general decline, we conjure up a period in the past when life was good, when children and serving personnel knew their place, when trains and buses ran on time, and when high quality at a low price was assured. The field of education is notoriously prone to such beliefs...(p. A23)

In this alternative interpretation of Canadian higher education, the attribution of declining standards to the rising generation may be a mere epiphenomenon of the life cycle, exacerbated at the present moment in Canadian educational history by the aging baby boom effect noted by Foote and Stoffman (1996).

Clearly, issues of trends in educational standards must be approached with an open mind and with the best evidence obtainable. The present paper reports on The University of Waterloo (UW) as a case study, with reference to levels of preparation in students' mathematical skills. The study is confined to those disciplines for which mathematical skills are central in part since concern about standards at Waterloo has been publically voiced with express reference to mathematics, but also because mathematical skills are more easily measured than arts skills such as rhetoric or essay writing.

While the data are not necessarily representative of all Canadian or even Ontario universities, they do bring some unique leverage to the problem outlined above. First, this case study arises specifically from a contention among some UW faculty members that the decline in skill among first year entrants had by the mid 1990s become acute (Vrscay, 1996). Thus, we begin with an intuitive hypothesis from faculty members who deal with students on a daily basis and within the context of some of the more selective programs at Waterloo, where there is sensitivity to the maintenance of standards. Secondly, we employ not only test score data from mathematics diagnostic instruments, but also perceptual data from a survey of teaching faculty members. The two types of data enable certain conclusions to cohere, as shall be outlined below.

SPECIFICATION OF THE PROBLEM AND METHODS USED

Preliminary Interview

We began with a group discussion and interview — one could almost term it a focus group — with five professors from UW's Faculty of Mathematics. This helped in defining the problem and key variables. We were directed to first year students as the key group to examine, since problems of diminished standards or expectations at the University were linked so emphatically to a perceived decline in high school standards. Our sources felt that some catch-up may occur during the university years, so that the graduating students are not necessarily much inferior to their predecessors. It was noted that diluted standards might be revealed both by the amount of material covered in first year classes and by the "belling" or upward adjusting of grades. A problem of administration pressure to bell was cited several times. One of the informants visualized the problem mainly in terms of the changing expectations of first year students regarding the amount of work required of them. A consequence, we were told of the "special me" and "self-esteem" fixation in the schools was that first year university students underestimated the amount of work required to acquire mathematical proficiency. In this argument, once the attitudes and expectations are turned around, students today perform as well as ever. A ten year time frame was suggested for our study. The main decrease in the academic preparation of students was traced to the late 1980s and early 1990s, continuing more gradually to the present. To examine a more extended time frame would also have led to difficulties in finding sufficient respondents for the opinion survey component of the present research, due to the recent wave of retirements at the University.

It became clear from the group interview that some challenging research design issues lay behind the questions being raised. The main problems are (i) that each year's incoming class could differ from its predecessor for reasons beyond the content of the high school curriculum (see also, Casas & Meaghan, 1995); (ii) that academic preparation may be subject to lateral "skill shifts" that are neither higher nor lower than before, simply different.

As for the first point, each year's first year class is shaped by demographic shift, by the priority high school graduates give to acceptance at UW, and by decisions University authorities make about the admission standard and size of the incoming class. In the ideal design, we would have begun the study long ago, each year gathering data on students' demographic background, high school grades, IQ, and study habits/attitudes. And we would have administered a fixed diagnostic test at the beginning and at the end of each student's university career.

Would such a test be even theoretically possible? The group interview with mathematics faculty raised some doubts. It was noted, for example, that with the growing accessibility of computers and software, mathematical operations that once were important skills for students to have at their fingertips now are handled by computer applications. This could mean a switch from an operational to a conceptual emphasis that would amount to a lateral, not a vertical, skill change. It is analogous to an occupation that neither gains nor loses skill demands with the introduction of workplace technology, but instead simply changes in skill profile.

These doubts about the measurability of trends in mathematical skill underscored the need for perceptual data to stand alongside a time series of results from diagnostic tests.[1] The impressions of classroom lecturers could, conceivably and paradoxically, be more accurate than test score trends if it were true that lateral skill shift was occurring. Thus, simultaneously as a search was undertaken for sources of data for entrance level mathematical ability, a perceptions survey of UW faculty members from certain departments was designed. We shall describe first the data from diagnostic testing in mathematics.

Longitudinal Data on Mathematical Ability

Each September, in the week prior to commencement of lectures, The Faculty of Engineering at UW administers a "Mathematics Preparedness Test" (MPT for short) to all of its incoming class. The exam was designed to improve first year performance and is used as an early identification tool to determine which students will likely have difficulty in the engineering programs so that assistance can be sought before problems arise (Ford, 1995). The test is revised every three years. The pair of MPT time series for 1991–93 and 1994–96 were considered by an informant we interviewed in the Engineering Faculty to be highly comparable. For 1997, however, the test paper was changed more fundamentally to accommodate its administration to Faculty of Mathematics first year students along with the engineering class. The version for 1997–99, so our informant advised us, is not comparable to the earlier ones. In the analysis presented below, each three year series is modeled separately, as a stand-alone set. Conclusions are attempted regarding overall trends by examining internal trends within each set of three years, and with awareness of the greater similarity between the 1991–93/ 1994–96 instruments than between the most recent data and either earlier series. These data cover 6,194 students in total.

The MPT is divided into six different sections comprising logarithms, geometry, trigonometry, algebra, analytic geometry and differentiation. From 1991 to 1996 there were 31 questions, five per section except for six in the algebra section. Copies of these tests can be found in Coutts (1997, Appendix B).[2] The post-1996 version used 25 questions.

The Opinion and Perception Survey

Given the impossibility of turning back the clock to test and interview students from past years, an alternative strategy was to measure the perceptions of instructors of first year courses at UW. A short survey was designed for this purpose. The complete questionnaire is in Coutts (1997). Initially the Mathematics and Engineering faculties were chosen for the survey, but later in the research the faculties of Science and Applied Health Sciences were added for a confirmatory test of some first impressions.

The eleven question survey was initially administered by e-mail in March 1997. Since anonymity could not be provided by a survey returned through e-mail, respondents were given the option of printing the survey and returning it via campus mail. The sampling for the initial survey began with names of professors in the Mathematics and Engineering faculties who, according to listings in the undergraduate calendars for 1986–87 and 1996–97, had instructed at the University of Waterloo for at least ten years. Lists of professors who instructed first year courses at any time during the past five years were then obtained from the First Year Engineering Office and the Faculty of Mathematics Dean for Undergraduate Studies, giving the final sampling frame. The historical records to capture just those with ten years of continuous first year teaching were impossible or at least impracticable to obtain. The number of faculty who have such extensive experience teaching first year students is probably miniscule in any case. We envisioned the survey respondents as informants who were reporting in part the general impression within their own faculty, verified by at least some personal knowledge.

Since the sample gave only 33 (of 57 potential) cases even with our relatively loose criteria, the survey was, as noted, later administered to the Science and Applied Health Sciences faculties to determine if the results of the initial survey were reproducible. Similar to the Mathematics and Engineering faculties, Science and Applied Health Sciences were chosen due to the less subjective nature of grading in those faculties relative to Arts and Environmental Studies. The sampling frame had to be slightly re-defined for this Science and Applied Health Sciences sample. Although again selecting those with ten years service at UW, as per calendar listings, we had to use the Course Information Report for Fall 1997 to identify recent first year teaching activity. The population was thus defined a little more restrictively for the Science/AHS portion of the survey. The new fieldwork took place by e-mail on October 9th, 1997. Two weeks later, and due to a low initial response, a follow-up copy was sent to the science/AHS sample through campus mail to confirm that all potential respondents received the questionnaire.

The response rate across all faculties surveyed was still discouragingly low, about one in three on a sampling frame with N = 78, and so in the winter of 1998 yet another contact was made, by campus mail, with all nonrespondents. We were mindful that some one-seventh of university faculty contacted in any one term may be hard to reach due to sabbatical leave, and further suspected that in part the low 1997 response was attributable to those who, feeling unqualified to give definitive answers to the issues raised, self-selected themselves out of the sample. The new cover letter stressed that all views would be useful even if the instructor had not taught first year courses continuously over ten years. A question was added to find out exactly how extensive the first year teaching experience was. As already reported, the survey was only sent in the first place to those known from administrative records to have taught first year students at some point over the previous five years. The 1998 questionnaire was trimmed slightly by deleting some questions which did not prove important in analysis of the first wave responses. The February 1998 follow-up generated another 23 cases, and also gave us confirmation that three people in the sample had retired and were no longer connected with the University. In all, 52 out of 78 eligible instructors answered the survey. The final response rate of 67% is consistent with previous experience of surveying faculty members at UW and indeed of many samples surveyed within organizational settings (Goyder, 1987).

The survey, being retrospective and historically incomplete insofar as not every respondent taught continuously at the first year level since 1991, is not a full triangulation of the Mathematics Preparedness Test. Moreover, the survey data base permits only the most rudimentary statistical analysis, and yet the survey is far from valueless. Each of these respondents, after all, taught hundreds of first year students. We shall demonstrate below that, in a general way, the two sources of data reinforce each other. The faculty survey had value if only for the ideas it generated for interpreting the time series of MPT test scores. The depth of experience tapped even from this limited survey became apparent in the extended write-in comments volunteered by many respondents and frequent reference to this material appears below.

RESULTS

Mathematics Preparedness Test

The MPT data were analyzed using dummy variable multiple regression analysis, with gives the same information as analysis of variance while adding size of effect estimates (Cohen & Cohen, 1975). These results appear in Table 1, along with some descriptive statistics.

Each set of coefficients is a self-contained model, as explained previously. Test scores were released to us in grouped form. For data covering 1991 to 1996, these are categories grouping number of questions correct into threes (except that the first category stands for zero or one correct), for the 31 questions posed in the test. The scores entering the regression models are midpoints for these categories. The final three years grouped 25 questions by twos, and again midpoints were entered. There is no purpose served trying to transpose the scores into a common metric (e.g., percent correct) because, as noted already, the 1991–96 series is not comparable to that for 1997–99.

To illustrate the meaning of the table, for the 1991–93 series, 1991 is the reference category (set to zero; see Cohen & Cohen, 1975: ch. 5 for explanation). The coefficient of –1.777 shows that students taking the test in 1992 scored about 1.8 (rounded) fewer questions correct than did their 1991 counterparts. The next year's decline was 1.842, again rounding to

Table 1
Regression of MPT Score on Year of Test

	Regression Coefficient (B)	% Variance Explained	Descriptive N of cases	Statistics SD
Model of 1991–92		1.8		
1991 (set to zero)	0.000		708	5.99
1992	–1.777*		660	6.44
1993	–1.842*		662	6.66
Intercept	16.500			
Model for 1993–96 (new version of test)		0.4		
1994 (set to zero)	0.000		671	6.60
1995	–0.303		711	6.59
1996	+0.691		650	6.44
Intercept	13.378			
Model for 1997–99 (new test and enlarged population of students)		0.3		
1997 (set to zero)	0.000		777	5.65
1998	–0.311		748	6.02
1999	+0.447		607	5.67

• $p < .0001$; all others have $p > .05$ ns.

1.8. Essentially here we would conclude that each year's class was getting nearly two fewer questions correct than in the previous year, rather a notable decline.

The variance explained computation, however, makes another observation about the data. There is considerable variance in the test scores for each year (Table 1 includes the standard deviations), and they are close to normally distributed, meaning that many students achieve a middling result, a few do very well and a few very poorly. The decline in relation to this overall variance is rather subtle (hence the variance explained figure of 1.8% for the 1991–93 series in Table 1).

A major conclusion of our analysis is that most of the decline occurred in the early 1990s part of the series. The models for the 1994–96 and 1997–99 series each reveal minor, non-statistically significant fluctuations.[3] The changes here are in terms of fractions of one question correct (e.g., from 1999 = .447 more questions correct compared to the 1997 baseline). Variances explained by across-year mean differences now are miniscule (and n.s.). It is convincing that a sharp drop in the early 1990s, with a tapering later, was predicted by our informants independently of the time series just described.

Multiple regression analysis has the added strength beyond simple anova (analysis of variance) that smoothed trend lines can be fitted by scoring year as continuous variable (in place of the dummy codes presented in Table 1). Taking the three sets of data separately, these trend line slopes are just as would be expected from the year-by-year figures already seen. The trend is thus $B = -0.930$ (significant at $p < .0001$) for 1991–93, levelling to the small (n.s.) positive figure of .342 for 1994–96 and +0.200 (n.s.) for 1997–99. If, and this may be a large if, the 1993–96 version of the test was of equivalent difficulty to the earlier one, then we can see the downward trend as extending from 1991 up to and including 1995 (B coefficient for those years = –0.822).

The downward drift seen least ambiguously in the 1991–93 series for the Engineering Mathematics Preparedness Test at UW collates with similar data collected at the University of Western Ontario by mathematics professor Christopher Essex (1997). To measure a suspected decline in academic preparation of first year engineering students at Western, Essex and several colleagues took a 20-question mathematics diagnostic test first used in 1984 and re-administered it to the 1992 class of first year engineering students. Both in 1984 and 1992 the test was administered during the "opening weeks" of university, with the data on the header page of the test simply changed from 1984 to 1992 for the later sitting. Essex (1997) has published results in graphic form in his own report, but for present purposes we read off the graph in order to transform his data back into numerical form and re-analyze them. In the Western data, we compute the average (smoothed using OLS regression) decline in score over the nine year interval to be just over half a question question (.592) correct per year, not too different to our 1991–95 coefficient of –0.822 from above.[4]

Professor Opinion Survey

In answer to the fundamental survey question, 47% of respondents felt academic preparation of first year students decreased relative to first year students in 1987 while 41% perceived no trend. Just 12% perceived an increase in preparation as of 1997 relative to 1987 (see Table 2).

Three factors might account for this dissensus among instructors. First, as seen above, there is more than one trend in the time series data. In the early period, and reproducing the findings from Western for the mid-1980s to 1992, erosion of preparation level from high school did occur. By the mid-1990s however, the trend line had leveled out to essentially a steady state. Maybe it is to be expected that results from the survey of faculty member perceptions gave rather divided views, especially given that the years of exposure to first year students does vary within the sample, and the sample size is too small to control this. Secondly, perhaps the division of opinion is re-articulating the point made earlier about how the decline in scores on the diagnostic test accounts for a very small portion of variance, even in the crucial 1991–93 period. Both stronger and weaker students come to the University every year, and as seen in the statistical results the dominant source of variation derives from these differences from individual to individual. A third factor would return attention to the de-skilling vs. lateral skilling issue broached earlier. Dissensus among respondents would indeed occur if some respondents interpret substitution of pencil and paper computational knowledge with computer software manipulation knowledge as skill loss, others as skill lateral shift.

As already explained, the number of faculty combining ten or more years service at UW with extensive first year teaching was just under 80, and the proportion responding to the survey still less. Even this modest data base, however, suggests some differences in perception

Table 2

From the Survey of Faculty Members

In your opinion, has the quality of academic preparation of first year students in your faculty increase, remained constant or decreased since 1987?

% Saying	Increased	Remained Constant	Decreased
All respondents	12	41	47

Would you agree or disagree that current first year students expect to do less work on their courses than their counterparts a decade ago?

% Saying	Agree	Disagree
All respondents*	38	62

Do you "bell" (that is, adjust) the grades of first year students?

% Saying	Yes	No
Mathematics	75	25
Engineering, Science & AHS	26	74
		p of difference < .002

Do you feel pressure to "bell" the grades of first year students?

% Saying	Yes	No
Mathematics	69	31
Engineering, Science & AHS	20	80
		p of difference < .001

Compared to 1987, do you feel the competence of students at the time of graduation in your faculty has increased, remained constant, or decreased?

% Saying	Increased	Remained Constant	Decreased
Mathematics	6	47	47
Engineering, Science & AHS	29	56	15
		p of difference < .03	

*Percentage includes an imputation to correct for an incorrect skip instruction which mistakenly moved ten respondents beyond this question. The imputation — by discriminant analysis using as predictors perceived pressure to bell, belief that high schools not sufficiently challenged, and feeling that competence of UW students by graduate has declined — adds one "agree" and eight "disagrees" to the raw count. In all other questions item nonresponse is a minimal one case or so, herein deleted. On the first two questions, not broken down by faculty, the difference between Mathematics and other faculties is not .05 statistically significant.

across faculty academic units. The greatest sense of decline in preparation among incoming students occurred among mathematics faculty respondents. These instructors also reported the most concern about administration pressure to bell grades upward, they were the most likely to see a problem in student expectations of reasonable work load, they tended to report having to dilute the difficulty level of their exams, and they were the most pessimistic about the quality of UW graduates. One informant, on seeing the results from our survey, pointed out that even outside the mathematics faculty, in engineering for example, much of the first year curriculum is devoted to mathematics courses. Since most of these are taught by staff from the Faculty of Mathematics, it is these instructors who are the most likely to witness, and have to deal with, problems of transition students encounter between high school and university. Implicitly, according to this argument, the early 1990s decline in standards in mathematics was a particular weak spot within the secondary school system, rather than simply one marker of a larger syndrome.

On the expectations issue, many write-in comments were offered by survey respondents. One mathematics professor stated "I have been astonished that my students in Mathematics do not work as hard as students did 10 years ago. I can not speak for their expectations. They do not live up to mine." Another mathematics professor gave this comment:

> ...what is a more serious problem is the attitude of students. I think that we have been able to address this issue in our own department undergraduate curriculum. A clear message is sent to the students that we expect them to work. To their credit, many do respond to the challenge... The modern philosophy of 'self-esteem' and 'outcomes-based' education has been responsible for a decrease in the expectations from students — the material actually being taught is of a more superficial nature (esp. in mathematics and science). This has naturally led to a change in the attitudes of students. They have a much different attitude of what 'work' is as compared to students from even 5–10 years ago. I think that we have done a good job in keeping the waters of mediocrity from flooding our institution as far as (a) impressing upon students the need to

> develop critical thinking skills and solid work ethic and (b) teaching them the essentials of their chosen disciplines.

According to one engineering professor, students "are willing to work hard, but they want to be spoon fed in a different way. They process information differently." Another engineer offered this explanation of the expectations of students: "I ascribe the changes to a philosophical change in our treatment of first year students. Previously standards were set high and a considerable portion of students flunked out or withdrew in the first year. This helped motivate all students and also ensured that the remaining were at least minimally capable. Now the philosophy is to retain all entering students if possible. The new approach is probably more humane, but can't help but result in lowered standards." A mathematics professor offered a solution to adjust the expectations of first year students:

> Today's students are more strongly motivated by fear of not being able to get a good job, and they seem ready to work a little harder... What is certainly clear to me is that, despite the fact that most high school math teachers are competent, students are not given enough work to do. First year is a terrible shock for many of them. Also, for what ever reasons, their grades may not reflect their relative abilities, which is tremendously tough on them, because they are basing their expectations on faulty premises. The kindest thing we could do would be to institute entrance exams of some sort, just to let the students know where they really stand relative to their classmates.

Criticism of the school system was widespread across the survey. One of the science professors articulated the notion that "...the public school system shortchanges OAC graduates by failing to provide them with essential skills in reading, comprehension, expression (within the bounds of grammar, spelling and punctuation, that is), and numeracy." An engineering professor told us that "the school system in Ontario, as before, does not challenge the best students." One mathematician offered an example of the lack of challenge encountered by students in high school: "students will acknowledge that in high school they were never given a problem they couldn't immediately solve." Another mathematics professor expressed fears about changes in high schools: "I worry about the changes we are witnessing in our high schools. I believe that things that are taught there now will become part of our curriculum in the relatively near future. I think that we are not prepared for this shift of responsibility."

According to another mathematics professor, however, high school performance is only one of many aspects that affect students' performance. This informant said:

> I have, on several occasions, taught two sections of first year giving the same lectures, problem sets, tests, and examinations, and had as much as 7 or 8% variation in their final grades. Sometimes I can trace it back to incoming high school performance, but more often not. There are a lot of parameters which affect student performance.

About three-quarters of engineering respondents indicated that they cover the same amount of material in current first year courses relative to first year courses in 1987. One of the mathematics professors, however, thought that:

> ...students are learning less since [their] curriculum has become 'watered down' (less courses, less material)... However, administrators are reacting quite prematurely and rather irresponsibly to perceived threats of future decreases in enrollments. There are pressures to dilute the curricula even further.

An engineer responded that "students may be less well prepared, but not less competent." Similarly, another engineering professor stated that "students now are as intelligent as before but are not drilled as well in the fundamentals of algebra, geometry, English, physics and chemistry. Their learning and knowledge seems more superficial." And finally, a mathematics professor articulated a theme we first heard in the group interview:

> ...the style of questioning, especially for more complicated problems, has changed. There has been a trend to structure questions in a way that leads a student from the beginning, along a series of steps, toward the final goal. Rather than just asking, 'prove or show that...' we now first ask the student to

> write down a relevant definition or theorem, (in essence a pretty big hint) and then take that information, make the appropriate substitutions, etc., to eventually arrive at the desired goal... problems in current exams... are generally more straightforward and less challenging than in the past.

What do these comments sum to? One theme noticeably lacking is any anxiety that the diminished standard attributed by the university instructors to the public school system leads to permanent cognitive handicaps. It would have been intellectually fashionable (e.g., Blakeslee, 1996; Wilson, 1998) had the survey respondents voiced fears about permanent losses in potential due to insufficient stimulation of the brain chemistry. It intrigued us that these respondents, all natural scientists, engineers and mathematicians, conceptualized the issue put to them not in terms of synapses and neuro-transmitters, but in the much softer and sociological vocabulary of first year students' attitudes and expectations. As seen, the likelihood of recovery of standards following some first year trauma to the student's self-esteem was voiced by more than one respondent.

The survey responses thus do more than simply put flesh onto the statistical skeleton from Table 1. They point to interpretations, and temper the most pessimistic conclusions that might be reached from the numbers alone.

CONCLUSION

We became persuaded that indeed there did occur some dilution in the level of mathematical preparation of high school graduates entering the University of Waterloo. Our data picked up this trend as of 1991, and saw it level off by mid-decade. The Western data suggest the decline had been under way since the mid-1980s. Taken together, the various sources of data examined here point toward a real but historically specific period of change in mathematical skills among students entering UW. The change was tied up with student attitude and expectation regarding work, according to our survey respondents. The respondents also seemed to tell us that the changes concerned mathematics in particular, not so much non-mathematical, but still scientific skill or knowledge. It bears on interpretation of the data that the years from around 1985 to 1995 marked the coming of age of the home computer (Goyder, 1997), and diffusion of PCs into school classrooms. As our circle of informants had suggested early in the study, part of the issue around mathematical skills concerned the computer mechanization of some of the traditional operational skills. Clearly, the issue of eroding standards is controversial and multi-dimensioned. For us to interpret the findings with adjectives such as weak, moderate or strong serves no useful purpose. For assessing the substance of the early 1990s trend, the data must speak for themselves, and directly to the reader.

The low variance in scores explained by temporal change highlights the heterogeneity of students of each year. This heterogeneity, coupled with the recent leveling off in MDT scores, may be one factor accounting for the variant perceptions among course instructors. It was clear, nevertheless, that on balance more perceive slippage in preparation than an enhancement; the concerns raised by faculty members at the University of Waterloo were not just a nostalgia trip summoning up remembrance of things past, as our opening Shakespearian quotation phrased it. The trend detected with the diagnostic testing was large enough, for all the differences in definition and coverage between the MPT time series and the survey of faculty members, to trigger a corresponding perception among a plurality of the university instructors. Something happened in the school system during the latter 1980s and first half decade of the 1990s (see also Casas & Meaghan, 1995), and whether it was primarily administrative, curricular, technological or attitudinal one cannot say because such factors are tied up together.

The survey data revealed, however, another facet to the perceptions issue. At Waterloo, there seems to be a difference in workplace culture among faculty in Mathematics compared to sister faculties such as Engineering, Science or Applied Health Sciences. Differences between the faculties consistently pass .05 statistical significance even with the small case base gathered for the survey. Judging from the questionnaires, many mathematics instructors feel particularly pressured to adjust their grades. This aspect of the organizational culture of the mathematics faculty seems to make frontline instructors especially particularly sensitive to issues of standards.

Course instructors who feel pressured to inflate grades can point to several commentators who see this as a harmful aspect of the contemporary culture of Canadian university life. Bercuson et al. (1984), for example, deplored the growing equality between professors and students and noted classroom course evaluations of teaching as symbolic of the erosion of faculty authority. A recent CJHE paper by Brodie (1998) sustains that view in linking favourable course evaluations to easy grading. It is a theme echoed by Emberley (1996), who speaks of the "empowerment" of students within the Canadian university system over the past 20 years as a cause of grade inflation. According to Emberley (1996): "...many students believe and act on the belief that grades are negotiable, others see rules and regulations as being subject to personal review, still others think academic decisions are open to endless appeal" (pp. 99–100). He links such empowerment with the determination by government to increase accountability within universities. Further discussion on the issue of grade inflation appears in sources such as Easton (1993), Casas and Meaghan (1995), and Young (1997).

Perhaps inevitably, when two quite different sources of data (i.e., the MPT and faculty survey) are placed side-by-side, as many issues are raised as solved. For example, the conviction among some of the survey informants that under-preparation among university entrants is corrected after a reality bath in first year in a way trivializes the whole issue of preparation. If catch-up is that feasible, why worry about high school preparation?

Given such loose ends, we will end by underlining the value of continuing with diagnostic tests of the mathematical skills of incoming students. Future issues around standards, for example, around concerning the double cohort soon to graduate from Ontario schools, may thereby be better assessed by drawing methodological lessons from the early 1990s shock wave. Given administration resolve, much more could be done with diagnostic data. The tests might be linked with background information from the Registrar's files, or alternatively a short questionnaire gathering background information might be appended to the test itself.

As a reviewer noted, attitudinal and expectation questions should be included in such data-collection, given the outcome of the present study. Any such research should build in an independent assessment of the comparability of the tests used in different years, in recognition of the lateral skills issue we learned about from the interview with key informants.

Notes

[1] Perception is of course a form of reality that may have important consequences, but for present purposes this seems the simplest word for differentiating between the objective and the subjective aspects of the research problem.

[2] Complete available results by section and overall are contained in this source. For the most part the break down of results by section shows few differences in performance by year. The trigonometry, analytic geometry and geometry results show very similar distributions from 1991 to 1996. In 1995, the logarithms and differentiation results show slight declines in performance, but these differences are slight and the results return to similar distributions as previous years in 1996. The algebra section has shown the least consistent results of the six sections from 1991 to 1996. The performance of the students on the algebra section in 1991 was very high with most students answering between four and six out of six questions correctly. The 1992 results produce a very different distribution with many students answering only two or three questions correctly out of six questions. The algebra results improved in 1993, although not to 1991 levels, and remained fairly consistent from 1993 to 1996.

[3] Although the test is administered to all engineering students, making for a population rather than a sample, the results can be regarded as sample data insofar as we are drawing implications for University of Waterloo students in general.

[4] Some of our informants in the Faculty of Mathematics examined the Essex test at our request, with a view to addressing the lateral skills issue. Their conclusion was that, while a core of some 5 to 7 of the 20 questions could be considered valid in any period, at least three concerned issues less important in 1992 than in 1984. In other words, our informants were inclined to feel that to some degree the 1984 to 1992 comparison had exaggerated decline in skills among first year students at Western.

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