8. If I have new ideas about teaching mathematics, how can I be sure that I succeed in implementing, evaluating and extending them?

9. How can assessments be designed in order to complement good teaching so as to promote further opportunities for learning?

10. Are problem-solving and theorem-proving the only relevant elements in assessment?

11. What contribution could 'academic councils' make to the development of effective teaching?

12. What structures are necessary in my institution to support and promote effective teaching?

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Linking Mathematics with Industrial Problems

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There is a growing interest in establishing links between University Mathematics Departments and industrial and commercial organizations in order to identify industrial problems amenable to mathematical analysis. There is a variety of reasons for this including:

1. the desire of mathematics faculty to contribute to the solution of real life problems;

2. the desirability of involving graduate students with such problems;

3. offering industry the opportunity to view the useful mathematical expertise of graduates with possible resultant job offers;

4. the desire by industry to create links with mathematics faculties to avail of faculty expertise and to aid in student recruitment for the company;

5. the desire by industry to avail of technical expertise in areas of shortage of such expertise in the company.

As a result, a number of Universities in different parts of the world have established such links. The type of link varies somewhat from place to place. Probably the oldest continuing link scheme (running for more than fifteen years) is operated at the Mathematics Institute, University of Oxford, U.K. where a one week study group is held annually involving Oxford faculty members (augmented by invitees from other Universities) graduate students and industrial participants to discuss and hopefully outline solution paths to industrial problems. With initial help from Oxford faculty a similar one week study group is now held annually at both Rensselaer Polytechnic Institute in the USA and at C.S.I.R.O. in Australia. A different type of process (also running for more than fifteen years) is operated at Claremont Colleges, California, USA, where the postgraduate education of mathematics students is through involvement with industrial problems funded by industry and identified by

faculty with an industrial partner. In return for funding, Claremont Colleges contracts to deliver material specified in a contract. The TechnoMathematics Group at Kaiserslautern University, Federal Republic of Germany and the Mathematics Institute, University of Linz, Austria also have well established links involving the education of mathematics students through the solution of industrial problems although at these Universities the procedure is less formalised than in the Oxford model. The TechnoMathematics Group at Kaiserslautern has particularly strong links with the German automobile manufacturing industry while Linz has particuarly strong links with the electricity supply companies and the chemical plants in Austria.

Similar initiatives have begun in Ireland and in the recent past a workshop in Applied Mathematics was held at NIHE, Limerick, in the first of what is planned to be a continuing series. The objective of the workshops is to involve the mathematics faculty and postgraduate students at NIHE, Limerick in real applications of mathematics in both the manufacturing industry and commercial organizations; the workshop participants offer help to industry in solving problems that appear to be amenable to mathematical modelling and analysis.

The task of identifying a set of suitable industrial problems for the workshop required substantial effort on the part of three mathematics faculty members, despite the fact that (1) NIHE, Limerick has well-established industrial links through its industrial placement program, which is an integral element of all degree programs; and (2) the range of potential problems was wide in that problems were regarded as acceptable if adequate relevant expertise resided in the mathematics faculty (augmented by faculty from other departments at NIHE, and, possibly, by support from faculty of other universities).

The three problems considered at the workshop were of widely different types: (1) wave-induced washout of submerged vegetation in Irish lakes; (2) creep behaviour of ultra-high-molecular-weight polyethylene under dynamic load, with potential application to the design of femoral prostheses; and (3) keg utilization.

Workshop structure

For this first venture, if was decided to confine the activity to one day so as to facilitate participation by both the industrial representatives and faculty and students from other institutions. During the morning session, each of

the three problems was described in detail by the industrial proposer of the problem.

In the afternoon, separate groups with appropriate expertise and interests that had been identified for each problem participated in discussion sessions. Each discussion session began with an introductory presentation of material related to the problem under consideration by an NIHE, Limerick academic. This presentation was followed by an open discussion chaired by the introductory speaker.

The objectives of the afternoon session were (1) to identify potential solution paths for the problems (if possible) and (2) to identify groups of academics who would commit to work on a continuing basis with the industrial presenters of the problems towards solving the problem.

Submerged vegetation washout

The problem on washout of submerged vegetation in Irish lakes was presented by the Central Fisheries Board, Dublin. The Irish Central Fisheries Board, which is responsible for monitoring and maintaining fish stocks in Irish lakes, has observed that vegetation growing on lake bottoms is sometimes washed away by the action of the wind on the lake surface. Since the vegetation is necessary for the health and survival of fish stocks, it is desirable to prevent vegetation washout; to do so, however, it is necessary to understand the mechanism through which washout can be predicted for a given wind speed, wind direction, and lake geometry. To achieve this, it is necessary to understand how the action of wind-driven waves on the surface of the lake is transmitted to the lake bottom to create stresses that cause washout of vegetation from the lake bottom.

For this water wave problem, mathematics faculty members from NIHE, Limerick with expertise and interest in fluid mechanics and wave problems were joined by fluid mechanics colleagues from mechanical engineering, NIHE, Limerick as well as experts in fluid mechanics and waves from University College, Cork and NIHE, Dublin. Joint work continues on this problem, and to date an initial model based on linear water wave theory has been developed.

Improved Artificial Joint Design

The problem related to the design of femoral prostheses was presented by a large medical products manufacturing company that provides the medical profession with a wide range of artificial replacement joints and limbs for the human body. At present, the company produces an artificial hip joint head that fits into a receiver cup made of a different material. The company wishes to replace the material now used in the receiver cup by an ultra-high-molecular-weight polyethylene (UHMWPE) material. To do so, it is necessary (1) to establish the response of the UHMWPE material to anticipated static and dynamic load; and (2) to establish a model for predicting the creep penetration of the metal head into the UHMWPE after N walking cycles and after various periods of use (days, months, years).

To consider these two linked materials and mechanical problems, a number of mathematics faculty members with expertise in numerical analysis (since numerical analysis is expected to play an important role in the modelling of these problems) were joined by materials and mechanical engineering colleagues from NIHE, Limerick and a materials expert from NIHE, Dublin. Work on the problem continues, aided in this case by the fact that a research professorship in mechanical engineering at NIHE, Limerick is sponsored by this industrial company and his work is substantially concerned with establishing the mechanical response of medical prostheses under static and dynamic load.

Optimising Keg Use

The problem of keg utilization was presented by a large brewing company. The company wishes to optimize the use of its keg population (used to transport its wide range of brewing products) for known current demand and future anticipated demand. The problem as presented at the wokshop was somewhat diffuse and not clearly defined. The background is that this company holds a population of approximately 800,000 kegs, purchased during a 20-year period and of three types (i.e. 51.1 L aluminium, 50.0 L aluminium, 50.0 L stainless steel). The company's four production centers serve three main markets, i.e., Ireland, Europe and the U.S., with a dozen different brewing brands. Identification of kegs/markets/products is currently done by color banding. A proposal within the company is to change to a universal keg (50 L stainless steel). Subproblems related to the general optimization problem are (1) how

to estimate and control/reduce losses in the current keg population; (2) how to measure and improve utilization in a situation in which return times vary widely in different markets, from one week to 18 months; (3) with a universal keg, how to monitor intercompany transfers (thre are a number of separate companies within the group) and how to allocate control over their own keg populations to individual companies.

The consensus reached by the workshop participants was that to make progress in solving this problem, the company needs a range of reliable statistics (currently not available) on the keg population and that the company needs to invest resources to provide the necessary data. Work on this problem continues, aided by the close existing contacts betweeen the Mathematics Department at NIHE, Limerick and this company which on a regular basis, receives applied mathematics degree students from NIHE, Limerick for industrial placement.

Conclusion

Review of the first workshop on applied mathematics in anticipation of planning for future workshops, clearly indicates that substantial expenditures of time, energy, and effort are required (1) to identify suitable industrial problems, (2) to organize an appropriate expert group to address a given problem, and (3) to ensure that collaboration between the industrialist and the academic group continues after the workshop, until an acceptable solution to the problem has been identified. it appears, therefore, that to continue the operation on an ongoing basis will require the expenditure of substantial human resources. However, there is considerable enthusiasm within the Mathematics Department at NIHE, Limerick for the organisation of further workshops.

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