CURRICULUM DESIGN IN UNDERGRADUATE MOLECULAR BIOLOGY

CURRICULUM DESIGN

FOR A THIRD YEAR UNDERGRADUATE LABORATORY COURSE

IN MOLECULAR BIOLOGY AND BIOTECHNOLOGY

By

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ABSTRACT

The curriculum for Molecular Biology 3A06 "Molecular Biology Laboratory" was evaluated according to J.J. Schwab's concepts of the practical. Persons were identified whose beliefs represented the four commonplaces of learner, teacher, subject matter, and milieu. These persons were consulted for their evaluation of the curriculum, using questionnaires and interview/discussions. The data were used to formulate suggestions for a revision of the course curriculum. Conclusions were drawn about the nature of the kind of deliberation which might take place in this particular setting.

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INTRODUCTION

Curriculum consists of the mutually interacting elements of the subject matter and the teaching environment, shaped by learner and teacher. Thus it can be widely defined as every action, effect, and material that is functionally connected with a learning process. In contrast, some authors define curriculum purely as an end, namely "all the planned learning outcomes for which the school is responsible" (Popham and Baker, 1970). For the curriculum planner the first definition is somewhat unwieldy and the second is much too narrow. A more useful definition that facilitates planning may be the sum of the ends and means that the educator envisions to be applicable and appropriate.

The traditional theory of curriculum development as advocated by Tyler (1975) and others has been revolutionized by the ideas put forth by Schwab (1969a), Walker (1971) and others. Schwab's concept of the practical as curriculum planning by deliberation and through the interaction of the four commonplaces has gained in recognition and validity as our capacity to access and process vast amounts of information has increased in the last decade. However, curriculm development in postsecondary education still shares very few characteristics with the practical. This seems even more regrettable if one considers that in postsecondary education the four commonplaces of learner, teacher, subject matter, and milieu, could be more easily accessed in a balanced way than is possible at primary and secondary schools. Three such indications are: the maturity of the students allows their inclusion in the deliberative process on an equal basis. The subject matter is usually much more closely defined which eliminates some uncertainty and facilitates the formulation of learning objectives. At the level of a third- or fourth-year science course the students are committed to a much narrower range of milieus as possible career paths than at earlier times. This makes it easier for the curriculum planner to choose milieu representatives.

On these grounds it appears that Schwab's concepts deserve even more consideration in the specific setting of postsecondary education than in other settings. Unfortunately curriculum planners at many universities tend to disregard them, the prime reasons being a lack of educational training in university faculty and a lack of resources.

This project constitutes an attempt to explore the potential of the practical for redeveloping the curriculum for a third year laboratory course in Molecular Biology and Biotechnology. Contributions from representatives of the commonplaces were gathered and possible suggestions for a revised curriculum were identified. The focus of the course is directed more toward applied science and methodology than other courses at the same level. This faciliates easier access of the milieu and narrows the spectrum of possible learning objectives.

The contributions from the participants were also analyzed to identify some of the characteristics which may be exhibited by an actual deliberation between the representatives of the commonplaces in this particular setting. To this end, the conceptualizations of the commonplaces by the different participants were outlined and compared. Possible problem sources for the deliberation and some possible solutions were also identified. Specifically, the following questions were addressed:

1. How are the four commonplaces in this setting conceptualized by the representatives of the four commonplaces?

2. Can the practical be used in curriculum development at the university level?

What possible conditions might apply?

3. How can a deliberation process be implemented in this scenario?

4. What are the likely outcomes of such a deliberation? Would the curriculum recommendations from such a deliberation be logistically feasible?

LITERATURE REVIEW

The Classical Theory of Curriculum Development

Traditionally curriculum development has been oriented toward transmission of a body of knowledge (Miller and Seller, 1985). The traditional orientation is supported by the so-called classical theory which is based on the work of Ralph Tyler and others. Tyler's (1949) original concept of curriculum planning was entirely prescriptive. It seemed logical that this "parcel" to be delivered determined what the product, the educated student, ought to be like. In other words, the learning objectives were considered predeterminable. The task of the curriculum developer then became reduced to three stages. It began with the planning stage, a systematic investigation of social and individual needs. Once these needs were identified, curriculum content was selected accordingly in the design stage. The content then dictated the choice of teaching methods in the production stage.

The traditional approach did not acknowledge a requirement for the individual's perceptions to influence the outcome of this process. This orientation leaves no room for choice and action. Furthermore, once the need assessment was completed and the objective identified, the means toward this objective were to be determined through the application of theory, without taking into account the particularity of the situation. The planning of curriculum was to proceed in a highly linear way, by screening the tentative objectives and learning experiences through a prefabricated philosophical structure and by the application of theoretic principles from accessory sciences such as behaviourist learning theories. The selection of learning experiences could be done by a single person totally unfamiliar with the concrete case. The sole purpose of the planning committee in Tyler's concept was to achieve a consensus on objectives. This purpose remained unaltered in a more recent revision of Tyler's (1975) concept, which recognizes certain "arational dimensions" in the process of curriculum planning.

The Practical

In his practical papers, Schwab (1969a, 1971, 1973, 1983) claims that the field of curriculum was moribund, had in fact stagnated to a point where a profound re-evaluation of its guiding paradigms seemed appropriate. A particular concern of his was the "flight upward" from the practical world as was evident with many curriculum theorists. He proceeded not only to offer an alternative set of theoretical criteria, but he translated this theory into a new strategy for curriculum development - the practical. His theoretical criteria were the four commonplaces of education, students, subject matter, teachers, and milieus. They were to receive equal consideration in the curriculum design, which takes place in the particular context of the concrete situation.

In most situations, an exhaustive representation of the four commonplaces cannot be facilitated by one person alone. Schwab (1983) therefore suggested a planning committee composed of specialists representing the commonplaces and accessory disciplines as deemed necessary, as well as other members for "conveyance of nonintellective propensities". The committe is chaired by a curriculum specialist, whose main tasks are to complement the group, to facilitate communication, and to maintain a deliberative mode of discussion by ensuring equal treatment of the commonplaces. This truly formidable workload for the chair is probably one reason why the implementation of the deliberative process has proved fraught with difficulties.

The deliberation was also envisioned to embrace subjective realities and values represented by the individual committee members. All these contributions can only be made by means of an efficient communication system both within the committee and outside. One role of deliberation is to facilitate such communication, which requires the breakdown of the traditional communication barriers between disciplines and the establishment of new communication channels such as journals. The dependence is a mutual one: The more interdisciplinary communication is improved in general, the easier deliberation will come about. Schwab offered little advice on the education of educators to participate in deliberation, another shortcoming which has impeded the proliferation of the practical to this day. For deliberation to take hold in a given group, a simultaneous process of mutual discovery, coalescence of discoveries, and utilization of the coalesced is required (Schwab, 1973). The chairperson plays a key role in this critical process.

Deliberation is initiated upon a given feeling of inadequacy of the existing situation (Schwab, 1971). It employs deliberation in its various steps from the perception of a problem to the implementation of a new piece of curriculum. The groundwork for this deliberation is laid by the participants using a variety of acquired abilities which Schwab (1971) calls arts of the practical and of the eclectic. These arts are to be used by each individual deliberator. The first step of the practical approach suggested by Schwab involves the translation of the initial feeling of inadequacy of a certain situation into one or more concrete formulations of the problem. This translation is accomplished through deliberation, whereby the group members make their contributions. The product of this problemation step is a set of concrete desiderata.

As the second step of the practical, Schwab (1971) suggests the design of alternative remedies with the objective of alleviating the problematic situation. These alternatives are generated in anticipation of their effects, by rehearsing them. Deliberation at this point has to deal with ends and means. This process leads into the third step, the weighing and choosing between alternatives for the most promising one. The chairperson has to ensure that the deliberation hunts out and juxtaposes all relevant considerations.

Schwab (1973) emphasizes that neither the generation of alternatives nor the consideration of them conclude when there is an agreement. Instead, he envisions the deliberation process to follow a spiral by adding more and more complexity to the body of underlying criteria. In addition to its potential for the generation of workable, long-lasting solutions, the deliberative process possesses the invaluable property of being educative in itself. Therefore, deliberation by itself represents a worthwhile investment in people. This educative value elevates deliberation above mere negotiation, where the objective is a compromise between two antagonistic standpoints.

The Naturalistic Model

In 1975, D.F. Walker documented a curriculum development project at Stanford University which was carried out under the guidance of Elliot Eisner. Walker was intrigued by the obvious discrepancy between the accepted theory of curriculum planning and its practise in the real world. His objective was to explore and verify this discrepancy and to characterize this group"s approach in a new light, unbiased by existing theory. Unfortunately Walker's test case was not representative of the many instances of curriculum planning he might have liked to generalize upon. Eisner's group consisted almost exclusively of his own disciples, in a purely academic milieu; of the four commonplaces, only the subject matter was represented. A more representative, school based project (with mandatory participation) would likely have been more heterogeneous. Also, their sole motivation was the deadline of the grant. As expected, the group's deliberation proceeded rather smoothly and according to a convenient schedule. Also as expected, the curriculum was never implemented. Walker constructed an intricate evaluation scheme by which he characterized the group's viewpoints and deliberation. Since the project was not representative of curriculum planning as practised in general, this characterization is of little concern here. However, Walker derived from it two important conclusions: First, that the practise of curriculum planning in this case differed profoundly from the traditional recipe. Secondly, that the observed differences warranted further studies in order to derive a naturalistic model describing the practise of curriculum planning. Walker observed a total of three curriculum committes to obtain data for his model.

A description of the naturalistic model was published by Walker (1971) shortly after Schwab's first practical paper. The model contains a number of significant features that serve to contrast it against Schwab's practical model. It comprises three elements, platform, design, and deliberation. The process into which these elements are combined appears to be driven by action to a somewhat lesser extent than the practical. Its structure is more linear and temporal, though not always strictly sequential, which supports that more static impression when one compares it to the spiral of the practical.

According to the naturalistic model, deliberation is employed from the beginning to form the group's platform. Each member contributes their individual platform, "the system of beliefs and values that the curriculum developer brings to his task" (Walker, 1971, p. 52). A strong point of the model lies in its emphasis on the role of values. The deliberative process is described as very similar to Schwab's description in the practical. Again, we see the principles of problemation, choice and action at work. The platform is thus synthesized from conceptions, theories, and aims as conceptualized contributions from individual deliberators. In addition, the members contribute less explicit platform components such as images and procedures.

A valuable contribution by Walker was the recognition of the nature of the driving force behind deliberation: It is "the desire for defensibility, for justifiability of decisions" (Walker, 1971, p.54). Thus, prospective deliberators can increase their contribution by trying to train their conscience into monitoring their justifiability. It appears that both the naturalistic model and the practical possess educative qualities.

Walker was obviously more concerned with contextual factors influencing deliberation than Schwab was, a consideration that was to be emphasized even more in the literature in subsequent years. Smith (1983) recognized the critical role of perceived "decisionmaking space" in deliberation. An absolute limitation to the scope of deliberation is provided by natural or circumstantial constraints. Within these, the deliberators have room to establish the structure of conventional principles inherent in their platform. This structure is then used as guidance in making decisions. Whether all the room at the deliberators' disposal is actually utilized depends on their deliberative ability .

The process of platform formation is often not explicitly concluded. Once the platform is sufficiently established (though not immutable) it serves as the basis from which the design of the curriculum is formed. By design Walker meant its complete set of abstract features, not the process of its formation. The explicit design can be described by the sum of the decisions that produced it. The implicit design is described by the unconsidered, subconscous choices that took part. The deliberative process in this context is described as the use of beliefs and information from the platform to make these decisions. On closer examination, this concept is again very similar to the practical, involving problemation, the design of alternatives, and the weighing and choosing among them. The process is simplified by the gradual emergence of a policy from a sum of precedent decisions. In case of indecision, additional data are provided by the use of eclectic arts. Walker went so far as to characterize deliberation as commonly a purely logical "argumentation and debate by a group of people". In this statement, Walker disregarded the sizeable platform component of ideals and values, the weighing of which is not always guided by logic.

On closer observation of the naturalistic model, it becomes clear that although its overall organization differs from that of Schwab's practical, its working elements are all represented in the practical. For instance, the emergence of a platform is implicitly recognized by Schwab (1973) as the discovery of "the loci at which each [deliberator] must begin to modify or contract himself to accommodate his colleagues' views and arrive at a collegiality which can function effectively in pursuing the task at hand" (p.519). As for the effectiveness of the naturalistic as a prescriptive model, it lacks one important extension:

the process of rehearsal as a deliberative element, which in Schwab's model is also represented by trial implementation as its action counterpart. Furthermore, its deliberation lacks the cyclic element of Schwab's practical which greatly contributes to the effectiveness of deliberation because of the resulting spiral structure.

Refinements of the Principle

In the years since the publication of the practical it has become increasingly apparent that a number of unforeseen obstacles are impeding its implementation - more than could be expected from a mere inertial clinging to the classical theory. Consequently there have been repeated efforts to expedite implementation, with a focus on "operatio-nalizing deliberation". Two components can be detected in these efforts. First, there was the attempt to clarify certain aspects of Schwab's concepts the understanding of which are thought to be critical and hampering the implementation of the practical. Most of these aspects concern the use of practical and eclectic arts. Addressing this legitimate concern is somewhat problematic because it invites undue emphasis on theory. Indeed, several of the contributions discussed in this section exhibit the symptoms of flight from the field as seems typical for conceptual work on the nature of deliberation (Hannay, 1989). The second component appears more promising; it is a hands-on approach of descriptive and analytical treatment of concrete cases of deliberation and their results. Unfortunately this approach takes time; to reap meaningful and useful generalizations from a group of concrete examples, the group has to be sufficiently large. This point may not have been reached as of yet. Nevertheless, each of the following contributions shows some potential to help operationalize deliberation in curriculum development.

Reid (1979) explored some of the theoretical and practical implications of Schab's concept of deliberation. He focused particularly on the critical role of the art of problemation in initiating deliberation. Although Reid did not explicitly question the nature of problemation as an art rather than a craft, he searched for and described "crafty" aspects of it that could be characterized in a prescriptive fashion. He arrived at a hierarchy of categories of problems that can be applied to facilitate the onset of deliberation by identifying the problems that deserve and require deliberative attention. Such problems have to be classified as practical rather than as theoretic, and as uncertain practical problems rather than as procedural practical problems. Uncertain practical problems are articulated by the question "what should I do?", and they require universal justifications rather than a mere claim of precedent or a disclaim of responsibility. Most, but surely not all curriculum problems fall into this category. The art of problemation is greatly facilitated by personal practical knowledge, the combined body of rules of practice, practical principles, and images, which guides a practitioner's actions (Elbaz, 1981; Ben Peretz and Tamir, 1986). Another essential art of the practical is the art of communication, to an extent that exceeds Schwab's (1973) original concept. Communication during deliberation not only has to convey data but values, visions, emotions, ideals, and other "higher order content". The concept of this "informing vision" has been recognized as an essential factor in the practical, and as one that may often be in short supply (Reid, 1984; Knitter, 1988).

The art of maintaining critical pluralism during the deliberation is also essential, as pointed out by Knitter (1985). By appropriate use of certain eclectic arts the deliberators can optimally utilize the available room - to stay with Walker's image. Using the example of "good in itself" (an abstract situation) compared to "good on the whole" (the same situation within a real-life context), Knitter (1985) illustrated the advantages of using critical pluralism. He offered little advice as to how to nurture the necessary eclectic arts, besides some long-term changes in teaching methodology, similar to Schwab's (1971) suggestions. Pereira (1981) suggested some strategies how to better familiarize graduate students in curriculum with the practical. Knitter (1985) did offer some explanations why critical pluralism so often becomes lost during deliberation. Critical pluralism can only be applied to uncertain practical problems, and our inherent tendency to reduce these problems to procedural ones is responsible for this loss. What is required of the deliberator is a change in the common attitude toward argument, and an ability to detach oneself from one's own viewpoint. However, proper problemation alone is not sufficient to ensure a fruitful deliberation. Since moral beliefs and values play an extensive role in directing deliberation, recognizing and "bridging" toward each other's value systems is also important (Atkins, 1986; Hannay, 1989).

To what extent can deliberation be codified? Pereira (1984) perceived deliberation as as an "essentially systematic method". He concentrated on characterizing the use of practical arts in deliberation, especially the art of perception as the initial requirement for the other practical arts to find application. Perception is often limited by habitual categorization and preconceived perceptions of the problem. To counteract this, the deliberator should be as detailed as possible in his/her analysis, covering all four commonplaces with appropriate balance. This leads to a development of the abstract commonplaces into concrete "particularplaces", through the use of a rich variety of differentiating collectives. These collectives should not be stereotypes but well defined, if necessary newly invented typologies. Schwab's approach of "deliberately irrelevant scanning" should be used to arrive at such collectives. As a future remedy to help operationalize deliberation, Pereira suggested case-specific analyses of deliberations. Although this is a useful suggestion he probably overestimated the extent to which actual deliberation can be characterized as systematic. The essentially rational character of deliberation (Reid, 1979; Hannay, 1989) cannot readily be taken to include a standard system. Perhaps it is the moral component of deliberation that limits its codification as a systematic method.

Notwithstanding the absence of a prescribable procedure, the facilitation of fruitful deliberation can be helped by publicising instances of successes and failures in past cases of deliberation. Harris (1986) noted that such cases could be best compared if a common framework or codified structure for the deliberative process were available. A certain degree of codification should be possible, since deliberation can be characterized as a craft. A particular deliberation should be codified by a balanced combination of persuasive, descriptive, and theoretical discourse. However, in her attempt to describe a procedure for codification of deliberation projects, Harris failed to avoid a popular pitfall: the flight upwards from the subject, as described by Schwab (1969a). Since the development of a procedure, like a recipe, requires a certain amount of abstraction and generalization, it is tempting to try and maximize the procedure's applicability by a large measure of generalization. Also, it is obvious that the procedure's applicability is lost if the generalization is excessive. It seems that Harris crossed that line in her attempt to describe a new "deliberative curriculum theory". The creation of another body of theoretical knowledge is likely to contribute little to the dissemination of the practical in curriculum development, despite the benefits of mutliple works of descriptive discourse. On the other hand, Harris was quite justified to criticize several much-cited, somewhat phenomenological accounts of cases of deliberation, namely Schwab (1969b), Siegel (1975), and Walker (1975), because of their unrepresentative scenarios. Much of these deliberations represented "lone- ranger approaches" (Roby, 1985).

In an attempt to encourage more critically reflexive behaviour by deliberators, Roby (1985) described the various habits - supposedly observed in actual cases - that impede deliberation. Although some of these habits had also been recognized by others (e.g. Knitter, 1985), Roby's list is the most complete, and it facilitates easy conceptualization through the attachment of self-explanatory labels such as "pet formulation" or "push to the solution". Some of these habits impede specific stages of deliberation such as the "solution end" or the "problematic start". As a remedy, Roby introduced nonlinearity into the concept of deliberation. Deliberators should be free to skip ahead or backtrack within the deliberative framework as outlined by Schwab. Deliberation should also include an initial, free- wheeling stage unhampered by strict adherence to the commonplaces. The proposed benefit should be an increased process of review and revision of the deliberative process, facilitated by the deliberative arts of critical reflection and backtracking. This exercise of critical reflection is responsible for the personal growth experienced by the deliberator. Further research is needed to determine what strategies might encourage this process of growth (Hannay, 1989).

Personal habits constitute only one of the obstacles toward the implementation of the practical. Political systems create impediments to the practical to varying extents in different countries and regions (Orpwood, 1985). In a wider context, Marsh, Day, Hannay, and McCutcheon (1990) outlined the position of school-based curriculum development within the specific political environments in Australia, Canada, the UK, and the US. As well, there are sociological barriers that impede the practical, such as the disinterest of university educators in educational theory noted by Stark and coworkers (1989), which seems to be complemented by an equally strong aversion of educational researchers toward educational practice (Schwab, 1971). The specific influences of such contextual factors on the deliberative process require further study (Hannay, 1989). As for primary and secondary school teachers, other important obstacles on a more personal level were suggested by Hannay (1989). First, erroneous classification of curriculum design as a procedural problem could be a mere result of curriculum design being scheduled routinely into teacher's timetables. Teachers often perceive a lack of jurisdiction or decision-making space to tackle curriculum design as an uncertain problem. The root of this problem lies in the unfavourable orientation that likely results if the teacher is mandated by legal or administrative requirements into participating.

In many specific settings it may not be logistically feasible to assemble a complete committee as Schwab envisaged it. But even assuming that a committee representing all four commonplaces can be formed the decision making process may be impeded by psychological problems between the members. For example, considerable discrepancies within the committee with respect to positions of power can negatively affect the dynamics of the group (Hannay, 1989). Such discrepancies can be expected between students and faculty at a university.

Lastly, another impediment may be a shortage of the appropriate leadership qualities in prospective curriculum chairpersons. These leadership qualitites are different from the ones identified for leadership in managerial positions. They were identified in two case studies by Hannay and Seller (1988) using a conceptual framework (Sergiovanni, 1984) that encompasses many specific kinds of leadership, including that of the deliberation chairperson. Further research is required to identify the best ways to help practitioners acquire the necessary skills (Hannay, 1989).

Case Studies

The benefit of descriptive codification of the deliberative process has been realized not only by Harris (1986) but by most authors in the field. The majority of the available descriptive case studies suggest that neither Schwab's practical nor the naturalistic model provide an accurate descriptive framework (Orpwood, 1985; Harris, 1986). It appears that most concrete cases - and the ones that are discussed below are no exceptions - reflect only parts of these models. The most comprehensive empirical study on school-based curriculum development in general by Marsh, Day, Hannay, and McCutcheon (1990) identified some factors which have contributed to the shortage of useful examples of school-based curriculum development. However, their focus was not directed specifically at deliberation.

Atkins (1986) described a case of curriculum deliberation for a transfer curriculum for minority students. She characterized the deliberation from three perspectives: each member's curricular position, the course of the process using Schwab's concepts, and the underlying values. Although the curricular positions were rather diverse, deliberation was facilitated by a mutual appreciation for the personal differences and a common concern for the students. The mutual tolerance prevented individual "lone ranger style" searches for definitive answers, which would have hampered deliberation. The process was characterized by a constant interweaving of the commonplaces, which happened unnoticed by the members. The process was hampered relatively little by the lack of initial problemation. Among the underlying values, little was observed in terms of technical, political, scientific, or aesthetic frameworks.

Fox (1972) used the example of a deliberation on a Botany curriculum to emphasize the real-life importance of some of the features postulated by Schwab. He pointed out the linear component of the process as starting in a concrete yet amorphous situation encompassing some perceived problem, and striving toward the development of specific materials and strategies. At the same time he attempted to demonstrate a spiral form in the pathway in between, as illustrated by e.g. the shifts in the location of the problem. For codification, he recommended written and audiovisual discourse and protocols, if possible including a pluralism of competing conceptions.

Hannay and Seller (1987), in their comparative treatise on three efforts of curriculum planning, managed to maintain the balance between the purely descriptive and the prescriptive generalizations derived from it. Their findings suggested and re-emphasized certain widely applicable requirements for deliberation to take hold and for decisions to be reached. The first is the classification of the underlying problem as an uncertain practical problem. As long as the problem is regarded as merely procedural, deliberation remains virtually impossible. This requirement had been previously suggested by Reid (1979), based on theoretical reasonings. Once the problem is recognized as uncertain, an atmosphere of creative consensus can take hold. This recognition does not necessarily take place in the beginning. An entire group of requirements is based on the powerful role of contextual factors, namely the source of initiation, the personal curriculum orientations, the supply and nature of leadership, and the availability of resources. These factors, only implicitly recognized by Schwab's model, can facilitate or prevent deliberation altogether. Another requirement lies in the essential role of values and of personal practical knowledge as contributing to the platform.

The two deliberations described by Hannay and Seller (1987) clearly follow a dynamic spiral structure as postulated by Schwab, rather than Walker's model. Several turning points are observed when a new dimension is added to the platform and applied to decisions. Both deliberations were found to alternate rapidly between commonplaces; incidentally, it repeatedly came to rest on the subject of teaching methodology, which induced the authors to suggest teaching methodology as a possible fifth commonplace. The process seems to be much less rationally guided than suggested by Pereira (1984) and Walker (1971) or even by Schwab (1969a). Little can be said about the success of the curriculum products. However, in at least one of the deliberations the experience of personal growth was noticeable, as members began to acquire qualities for facilitative leadership and participatory decision making.

Bonser and Grundy (1989) described the curriculum development for computer education at a rural high school. This deliberation was structured in a novel conceptual and organizational framework. It only took place among teachers at the school, with the researchers restricting themselves to the roles of "listeners and potential conversationalists". It consisted of four phases, each of which included a larger number of participants. In phase 1 individual teachers were interviewed. The transcript was returned to the participant for personal reflection and clarification after which a "jointly authored statement" was issued by the participant and the researcher. In phase 2 these statements were deliberated upon within small goups of teachers. This deliberation resulted in the planning of certain platform components. In phase 3 the small groups were drawn together for summarization and deliberation of the platform. This deliberation produced a body of information relevant to the development of a school policy statement about computer education. The actual statement was produced in phase 4. The procedure was not intended as an immutable sequence of fixed steps that would facilitate deliberation in many settings, nor was it regarded as the basis for the construction of a deliberative model. It was rather meant as a basis for action that would enrich the deliberative experiences of all participants, as well as an effective data- gathering device in this particular setting. It lacks some important characteristics of the practical, such as equal representation of all commonplaces.

The last four case studies all reflect an unequal representation of the commonplaces, through the composition of the groups as well as through the course of the deliberation. It would have been interesting to evaluate the subsequent implementations to get an idea of how detrimental to the results this bias could have been. Schwab (1973) considered an unequal representation of the commonplaces to be detrimental to the curriculum product as a whole. Yet in most practical settings the establishment of a committee composed of representatives of all four comonplaces may be logistically impossible. Hannay (1989) has called for research into alternative ways of effective commonplace representation, along the lines of Bonser and Grundy (1989). A certain bias in representation may be compensated through appropriate leadership (Hannay and Seller, 1988).

Another, less conventional structure of a deliberative process was chosen by Siegel (1975). In her development of a high school curriculum to teach Hamlet she simulated the process by assuming in turn the role of a representative of each commonplace. Through this simulated deliberation alone she managed to select from a collection of 101 alternatives a final array of four acceptable curricula. Her objective in this approach was to demonstrate how Schwab's work could be made accessible to a wider audience and how individual practitioners could employ the practical. This somewhat mechanistic approach runs contrary to Schwab's (1969) rejection of theoretic principles as being able to guide deliberation. It also reduces her deliberation to a procedure (Reid, 1981) governed by inflexible principles. It even shows a hint of the "lone ranger approach" criticized by

Roby (1985). Single-person "deliberations" were also reported by Roby (1978) and Schwab (1969a).

In summary, the complementation of theoretical discourse with case descriptions of actual deliberations - or attempts at deliberation - renders a comprehensive view of the role of deliberation in curriculum planning in public education. It also allows for some hypothesizing as to why the implementation of the deliberative approach in public education has been rather slow. In contrast, it says very little about the practice of curriculum planning in postsecondary education, the potential benefits of deliberation in that setting, nor does it allow an informed guess at possible obstacles towards its implementation there. The following sections focus on those questions.

Curriculum Planning at the Postsecondary Level

Traditionally postsecondary institutions have enjoyed much greater freedom from governmental prescriptions in curriculum design than has the rest of the school system. At most North American universities curriculum is designed at the levels of the faculty or college and the department. The former creates broad guidelines while the academic departments carry out most of the actual curriculum planning through curriculum committees. While these committees usually do not recruit any members from outside the department they do frequently include student representatives. Unlike in primary and secondary education where deliberation has even become part of the teacher education curriculum (Zeuli and Buchmann, 1988), the concepts of the practical have had little impact on curriculum planning in postsecondary education (McNeil, 1978). Apparently most university instructors find their curricula satisfactory, nor do they perceive a challenge of curricular decisions which would require their justification (Walker, 1971).

Fensham (1977) characterized curriculum in higher education by means of seven dimensions, in order to facilitate objective comparisons of courses and programmes and to help in monitoring and describing changes in a given course. His dimensions can also be used to identify needs and to design specific alternatives in curriculum development. They are applicable to programmes and - in most cases - also to individual courses. Most of them are not readily expressed as numerical parameters but they nevertheless serve their stated purpose. They fall into three basic groups:

a) Antecedents

1: Amounts of cognitive knowledge and skills the students have on entry (expressed as pre-test scores)

2: The amount of institutional response (in the form of remedial programmes) to differences in entry-level knowledge and skills

b) Transactions

3: The extent to which a programme or course relies on lectures as the primary mode for teaching and learning

4: The extent to which different rates of student learning are recognized by the teaching methods

5: The extent to which different learning types are accommodated by alternative

teaching methods

c) Outcomes

6: The extent to which students can determine the subject content

7: The extent to which continuous evaluation is used, as opposed to a single final examination

Little is known about the assumptions and influences that affect curriculum planning at the university level. Likewise, the process of curriculum change generally takes place in a rather uncoordinated manner, which is all the more surprising when one considers how well researched are the administrative processes at colleges and universities (Trinkaus and Booke, 1980). Nevertheless, a recommendation from the Council of Ontario Universities (Good and Trotter, 1972) towards a more systematic approach to course design and curriculum development did not elicit the desired action. Again, the minimum amount of dissatisfaction required to initiate change appears to be absent.

Other critics (Heger, 1975) have pointed out the need to restructure university curricula to dissipate some of the students' uncertainty about the nature of academic disciplines and academic research. They fail to realize that in the absence of a more balanced representation of the commonplaces the results of such efforts are bound to fall short of the expectations. Representation of the commonplaces in postsecondary education differs from public education in that the scholar often functions not only as the subject matter representative (Schwab, 1973) but also as the teacher. In contrast to secondary education, there is no higher academic authority that could aid the teacher with scholarly advice. The resulting dual representation, as well as a number of contextual factors render the scholar extremely influential in the curriculum development process. If, as Schwab (1973) asserts, "scholars, as such, are incompetent to translate scholarly material into curriculum" (p.501) the many problems with postsecondary curriculum should come as no surprise.

Stark and coworkers (1989) conducted a survey among 2311 faculty members at 97 colleges and universities on the factors that influence the planning of introductory courses. It revealed that the strongest influence is exerted by a faculty member's beliefs about his/her academic discipline. Most Biologists regarded their discipline as "an organized body of knowledge, that is, an interrelated set of concepts, ideas, operations, and principles" - rather than as "a group of individuals exploring common related interests and values" or as "a set of skills to be mastered and applied" (p.2). Independently of their academic field, 90 % of the faculty named as the most important purpose of education "teaching students to think effectively" (p.3). Nevertheless their selection of course content was based mostly on their beliefs how "the discipline can best contribute to other aspects of student intellectual and personal growth" (p.4). Faculty in Biology selected the content according to its potential to "promote learning of concepts and operations of the organized field" (p.5). In other words, the design of curriculum by faculty remains content-oriented. It does not follow their most important objective. The results of this project as well as other reports (Gibbins, 1988) support this notion.

As secondary, contextual influences on course planning the respondents in Biology named facilities and resources (e.g. textbooks and laboratory resources), opportunities, and assistance. Influences considered negligible in Biology were student characteristics, student goals, pragmatic issues, influences external to college, programme and college goals, advice available on campus, and literature on teaching and learning. Fewer than one third of the faculty reported pedagogical training as an influence on how they plan courses, reflecting a rather regrettable state of affairs.

With regard to the process of course planning, Stark and coworkers (1989) reported 62 % of Biology faculty stating that they select the content first, prior to considering other factors such as student characteristics, learning patterns, one's own background, and selecting materials and activities. The selected subject material in Biology was being arranged primarily according to the concepts of the fields (by 59 % of respondents), according to its chronological structure (by 21 %), or according to how students learn (by 10 %). It remained unclear how valid the faculty's conceptions of student learning were, given the general unconcern with pedagogical literature.

Based on these findings, Stark and coworkers (1989) designed a model which describes the current practices of introductory course planning at universities. They called it the Contextual Filters Model because of its main characteristic, the fact that faculty members' disciplinary views and related assumptions are "stable antecedents to course planning, essentially independent of context" (p.14). These assumptions are then filtered through and moderately affected by a series of contextual influences during the planning process. Although the strong influence of contextual features bears some superficial resemblance to Walker's (1971) naturalistic model, this procedure, being essentially transmission-oriented, exemplifies the behaviourist approach to curriculum planning (Tyler, 1975). It is characterized by a striking imbalance in the representation of the four commonplaces. Its lack of deliberation is also reminiscent of Roby's (1985) "Lone Ranger Approach" to curriculum planning.

Curriculum planning at the level of entire undergraduate programmes, e.g. an honors programme, can assume a variety of shapes depending on the definition of honours education, as outlined by Gabelnick (1986). Yet the generation of variety is stunted by the same shortcoming as described by the Contextual Filters Model: The focus of publications by Gabelnick (1986), Fensham (1977), and others is directed almost exclusively to the curriculum product, while the process of curriculum design appears to be implicitly understood as something that happens overnight in the instructor's office. As Schwab and others have eloquently shown, this approach tends to be ineffective in secondary education. There is no indication why it should be any more effective in postsecondary education. This oversight seems all the more surprising since it is generally recognized that the honours curriculum lends itself to a great diversity of academic presentation and of educational context. The reason lies in the smaller classes, higher student motivation, and greater average student abilities in honours programmes (Gabelnick, 1986). If any student deserves to be included in the process of curriculum design it is the university honours student.

University educators who do elaborate on the process of curriculum design tend to recognize the importance of learning objectives and of approaches to assess the success of the existing curriculum. The importance of detailed course objectives in higher education has been recognized by Schwab (1969b) and Beard (1972). A number of guidelines and suggestions for the preparation of course objectives by the university instructor have been published (Geis, 1972; Stice, 1976; Beard, 1972; Cox and Kontiainen, 1973). Yet despite the obvious benefits of specific objectives many university courses can still be found that lack them, and many university instructors do not go through the trouble designing them. A number of reasons for this have been proposed by Stice (1976) and by Cox and Kontiainen (1973), but the main reason may lie in the traditional method by which these objectives are supposed to be designed. This traditional method is again characterized by the behaviourist approach. Although the shortcomings of the behaviourist approach to curriculum design in primary and secondary education are now widely recognized, only traces of alternative approaches have actually spilled over into postsecondary education. Just as curriculum design as a whole, the design of course objectives is considered the responsibility of faculty alone. Objectives and specific teaching methods may be implemented, assessed, and redesigned according to elaborate procedures (Cox and Kontiainen, 1973), but the process discriminates against other commonplaces besides the teacher and the subject matter. The following case description serves as example:

In their design of a laboratory curriculum at Nottingham University Medical School, Short and Tomlinson (1979) note the absence in the literature of formalized test programmes for curriculum assessment. They equalize success of the curriculum with achievement of predetermined (and largely unalterable) learning objectives. Their assessment was in part based on consultations with the students through discussions and questionnaires but the questions are limited to minor variations in course content and to the success of specific "aspects of the laboratory classes". The mileu, as represented by the faculty and the medical community, is regarded as virtually omnipotent in determining the learning objectives. Yet they did not leave the task of redesign entirely up to the instructors: In at least one case, four third year students collaborated in assessing and redesigning a first year laboratory experiment, as an independent "miniproject". While Short's and Tomlinson's (1979) effort constituted a commendable beginning it is still a long way from an implementation of the practical as envisioned by Schwab (1969a). Its most obvious shortcomings are that the four commonplaces were neither recognized in their importance nor consulted in any equal, formalized manner, and even worse, that most of the learning objectives never even entered the discussion.

To summarize the point, the sentiment by many university instructors that the explicit formulation of learning objectives introduces a rigid mechanistic approach to education (Cox and Kontiainen, 1973) may be justified. However, the source of this confining rigidity may lie more in the process by which the objectives have traditionally been designed than in the objectives themselves. A recently proposed prescriptive model for course design by Malone (1991) recognizes this dilemma and suggests to replace current practices with a more reflective treatment of practical problems. While stopping short of explicitly involving all four commonplaces, this model includes a cyclical process of group deliberation and implementation, and has been successfully implemented at the University of Wisconsin, Stevens Point.

The underrepresentation of some of the commonplaces becomes especially obvious in the proces by which university curriculum is changed. In their study of the curriculum change process at three graduate schools of business, Trinkaus and Booke (1980) identified the participants, strategies, and tactics involved. They observed two distinct groups of participants: internals (faculty, administrators, students) and externals (trustees, alumni, community leaders, union officials). Of all these, the faculty was most instrumental in the change process, although there seemed to be a trend of increasing influence by administrators. The students were seldom actively involved although they did have a formal voice in matters of curriculum. The few student initiatives that were observed were overwhelmingly aimed at issues directly affecting the attainment of their degrees. Thus the underrepresentation of the student commonplace appears difficult to ameliorate. One feels much more justified to criticize the underrepresentation of the milieu. Especially in a graduate school of business, industry must be regarded as the major and indispensable representative of the milieu. Its exclusion seems difficult to justify. The occasional involvement of trustees, alumni, and community leaders observed by Trinkaus and Booke (1980) cannot compensate for this, especially since it seems to be viewed by the internals mainly as unwelcome but unavoidable meddling by outsiders.

Strategies, defined by Trinkaus and Booke (1980) as "the concepts of what is to be achieved, providing the broad parameters for action" (p.313), were of two general types: the pursuit of one's own goal-directed self-interests, and the response to the potential threat of power. Truly educational agenda are not even mentioned. The former take the two forms of advertising "utopian thinking" and efforts in "research dissemination". None of these are conducive to an effective process of deliberation.

Numerous tactics were employed in the pursuit of the above strategies. Trinkaus and Booke (1980) classified the tactics into fourteen categories. The most frequent one (15 %) was the formation of coalitions, followed by indifferent passivity, reciprocity, reducing and rotating the opposition (12 % each). Without delving into more detailed descriptions of these tactics one can characterize them without exception as either not conducive to deliberation or as actively hindering deliberation. The majority can be found almost verbatim in Roby's (1985) list of habits impeding deliberation. Its academic merit aside, Trinkaus' and Booke's (1980) description of the tactics makes rather amusing reading provided one can see humour in its authenticity. Assuming that the scenarios at these three graduate schools of business (one was public, two were private) are representative at least in their essence of the situtation in higher education in general it seems surprising that university curricula do not fail entirely. One is also induced to conclude that the creation of a more deliberative climate would require enormous political effort. A report about the implementation of learning objectives at the University of Guelph (Gibbins, 1988) implies the same. A study similar to Trinkaus and Booke's from a Dutch medical school (DeRoo and Moen, 1980) comes to similar conclusions even though it does not as openly question the parties' benevolent agenda.

Rationale for the Project

One first step towards a more deliberative style in curriculum planning is the discussion among faculty of learning objectives for courses, programmes, and postsecondary education in general (Beard, 1974). Naturally a meaningful discussion would require a change from the two strategies identified by Trinkaus and Booke (1980) to more altruistic and education-oriented paradigms. Even if such discussions do not lead to a consensus they nevertheless provide grounds for a thorough reflection by the instructor on what he/she really wants to accomplish. In fact, even the reflection itself is a valuable experience for the instructor (Stice, 1976). Elton (1983) claimed that many efforts to improve laboratory teaching in the sciences have become stifled by their disregard of learning objectives and their concentration on superficial innovations, mainly intended to keep pace with the development of the subject.

The second reason why the formulation of objectives is so valuable to learning lies in communication to the learner: informing the students of concisely formulated objectives can serve to defuse much of the uncertainty and inefficiency that hamper some students' progress (Beard, 1974; Stice, 1976; Elton, 1983). Such a communication can form the grounds on which the student commonplace could gradually gain influence in the curriculum planning process. The deliberation of learning objectives was a point of emphasis in this project.

The absence of deliberation and the discrimination against the student and milieu commonplaces are only two possible reasons why many university curricula do not achieve their objectives very well. Another reason, at least in the natural sciences, lies in a discrepancy between the course objectives and the means of student evaluation (Beard and Pole, 1971; Dressel, 1961; Elton, 1983). For instance, while the objective states for students to acquire skills for independent analysis and integration of information, the final examination might favour the reproduction of factual information. The discrepancy between stated objectives and practice of curriculum planning by faculty has already been mentioned. The frequent discrepancy between objectives and evaluation methods is another manifestation of the gap between what is said and what is done. Yet these discrepancies may provide useful points to initiate improvements, once they become obvious to the instructor. An additional reason for reconsideration of academic grading and testing procedures in general has arisen from the increasing consumerism, recent legal decisions on educational malpractice in the U.S., and far- reaching social criticism (Milton and Edgerly, 1977).

The conceptualization of the appropriate means for student evaluation for a given set of objectives was also emphasized in this project. Specifically, self-evaluation and peer evaluation were proposed to the participants as means to complement the traditional unilateral evaluation. There are indications that these alternative means do not negatively affect educational standards as is widely assumed (Boud, 1979; Boud and Lublin, 1983).

The success of a laboratory curriculum also depends on proper matching of objectives to methods (Elton, 1983). Product objectives (e.g. a scientific proof) can be achieved by relatively short and tightly prescribed laboratory experiences, while process objectives (e.g. the acquisition of certain skills) require considerable freedom in time, procedure, and apparatus (Elton, 1983). In an advanced course like MB 3A06 the majority of the objectives are usually process objectives. The choice of teaching methods are therefore infringed on by numerous limitations set by logistics and resources. Nevertheless the participants in this project were also consulted about their preferences in teaching methods.

The choice of subject material in MB3A06 had attracted little criticism. However, it was included a priori as one of the commonplaces into the needs assessment at the beginning. The content of the course in its current form had been determined by deliberation between myself and two members of the faculty (L.P. and T.F.), begining with a meeting in July 1988. At that time, T.F. proposed a series of connected experiments in E. coli genetics. Some experiments were chosen for closer examination but it was felt that the course should cover more than one organism. In a subsequent meeting in September a preliminary series of genetic experiments involving E. coli and Rhizobium meliloti was planned which included a library screen. Several of these experiments were adopted from a laboratory course at another university. The complementary section of yeast experiments in its present format was also agreed on at that time. In December 1988 a definite curriculum and timetable of experiments for the coming winter term were adopted, after some experiments from the bacterial part were eliminated for logistic reasons.

Based on the experience gathered during the 1989 term, a few minor changes were adopted in January 1990, such as elimination of mutant amplification and addition of a Rhizobium plasmid minipreparation. Since then no significant changes have been envisaged, with the exception of one of the yeast experiments (lac z - GAL induction on galactose gradient plates) which might benefit from a modification.

Description of the Project

The McMaster undergraduate programme in molecular biology and biotechnology was instituted in 1985. The first students graduated from it in the summer of 1990. Within the departments of Biochemistry and Biology at McMaster the programme is unique in that it is taught jointly and is supposed to be oriented toward applied science to a greater extent than other programmes in these departments.

This orientation toward applied science makes this programme even more apt for deliberative curriculum planning than most other programmes. The reason lies in the specific objective of the programme, namely to prepare the students for graduate research or for a position in the biotechnology industry. This allows one to identify prospective supervisors and employers as representatives of the milieu.

I was hired by the university as a part time sessional lecturer to design and implement a third year laboratory course in microbial genetics and biotechnology (Molecular Biology 3A06). The first version of the course was implemented in the winter term of 1989. It would be of great interest and usefulness to future versions of the course if further curriculum planning were carried out employing Schwab's concept of the practical. Beard (1974) suggests that most university departments could benefit from a routine reconsideration of learning objectives and other curriculum features. The results of the routine teacher/course evaluations held by the Department of Biology also suggest a certain potential for improvement, particularly in the the category of "organization of subject and course material". Such ratings of teaching by students can be used as objective standards in curriculum planning (Cashin, 1988).

Originally the curriculum planning was intended to proceed according to Schwab's (1973) spiral, which consists of successive rounds of data acquisition, deliberation, and implementation. However, trial implementations had to be cancelled after I decided on a career change for 1991. The project was reduced to a single phase of data acquisition, to be carried out during summer 1990. One objective was to explore the conceptualizations of the commonplaces by the participants in order to draw some conclusions on the possible shape and characteristics of a deliberation if it ever took place. Another objective was to formulate by consensus some concrete recommendations for the MB3A06 curriculum.

The project was envisioned to yield a number of benefits for postsecondary education in general and for the teaching of Molecular Biology specifically. First, the course itself should gain in effectiveness. The data obtained from the study can also be used in curriculum planning for other courses within the McMaster Molecular Biology and Biotechnology Programme, and for the programme as a whole. Depending on the outcome of the study a collection of general guidelines and expertise might be derived for deliberation in postsecondary curriculum development, especially for laboratory courses in the sciences.

METHODOLOGY

The project was envisioned to consist of four components that differed in the nature of work but that were not necessarily carried out in chronological order. They are the preliminary phase, the data gathering component, the evaluation, and the deliberation. The research methods included library search, structured interviews, and questionnaires. The four components are outlined as follows:

According to Schwab, practical curriculum planning involves the gathering of input from the four commonplaces (learner, teacher, subject matter, milieu), beginning with problemation. Accordingly, during the preliminary phase, the first and most prominent task in any implemetation of the practical lies in the identification of the ways in which the four commonplaces can be accessed. This is followed by the data gathering component, where representatives of the commonplaces were consulted. In the subsequent evaluation component, the objective was to explore the possibilities for a deliberation among the commonplaces, and to produce concrete suggestions for improvement of the curriculum. The fourth component, unfortunately, lay beyond the practical scope of the project: It would have involved an actual series of deliberation, implementation, and renewed deliberation.

The methods described in the following were designed largely during the preliminary phase. Some revision took place during the later components.

1. Selection of Commonplace Representatives

For representation of the four commonplaces, a number of categories of potential participants were identified. For the student commonplace, former, present, and future students would qualify. For the teacher commonplace, faculty and instructional staff would qualify. For the subject matter commonplace, anybody with sufficient experience in the respective literature and in the teaching of the subject matter would qualify, as well as persons familiar with the programme curriculum. For the milieu commonplace, prospective employers and supervisors would qualify. They could be identified more specifically from the history of past students. In principle, though, any faculty member or postdoctoral fellow in a biology-related field could serve as a representative of the milieu.

Specific criteria for the selection of participants from these categories were established and used to select specific persons to be contacted. Representatives of the four commonplaces were chosen if they fulfilled one or more of the following criteria:

- Involvement in the course, as teacher or learner
- Involvement in Molecular Biology research pertaining to the course content
- A general interest in postsecondary science education

A total of 13 students that had been enrolled in 1989 and 1990 were contacted through questionnaires. Six of them responded. Prior to 1989 the course was taught in a different format; students who took the course prior to 1989 would therefore not have been comparable in their responses to the students from the last two years.

As teacher representatives, two members of the faculty (L.P., T.F.) who contributed to the teaching of the course in its present form were selected. The head of the MBB programme (S.B.) was included because of his familiarity with the programme curriculum. The chairman of the Department of Biology (S.T.) was included for the same reason. Two graduate students who worked as teaching assistants (TAs) in 1989 and 1990, repectively, were also asked to participate. Only one of the latter responded.

As representatives of the milieu, four university faculty members were selected as potential graduate student supervisors or employers. One of them was from the Department of Microbiology at the University of Guelph (R.S.), one from the Department of Chemistry at McMaster (D.H.), and one is in charge of admissions at the McMaster Medical School (T.Co.). Additional milieu representatives were contacted but did not respond. All the participants are listed in table 1.

Originally I had intended to include representatives from the biotechnology industry as potential employers. However, none of the 13 students, nor any of the students from previous years that I know of, have chosen or even considered full time employment in the biotechnology industry. This became evident through personal conversations. They were all planning on academic careers, mostly in graduate school and medical school. For this reason the idea of contacting industry representatives was discarded. Some background material on the expectations of industrial employers is taken into account in the discussion (Fuller, 1980).

It seemed difficult to identify subject matter representatives that did not also represent other commonplaces. Faculty were either involved in teaching of the course or they could be regarded as potential graduate student supervisors which designated them as representatives of the teacher or the milieu commonplace, respectively.

2. Selection of Methods for Data Acquisition

For the acquisition of data, the use of questionnaires and interviews appeared feasible. Interviews could be expanded into discussions. Most of the data were obtained through questionnaires. Taped individual interviews were conducted with one student (T.B.), one faculty member (L.P.) and one teaching assistant (T.C.). The interviews were designed to complement the short written responses and to clarify some comments on the questionnaires. The importance of a spoken component in complementing written contributions in curriculum deliberation were noted by Bonser and Grundy (1989). The number of interviews remained relatively small because of their relative labour intensity and the difficulty in retrieving meaningful data from the interview transcripts which were at times compromised by the author's limited interviewing experience.

Two rounds of data gathering were carried out over a total of four months. The data from the first round were summarized into a consensus which was then put to discussion again, in the form of "second generation" interviews. Questionnaires were not used in the second round in order not to overburden the individual participant.

3. Design of the Questionnaires and of the Agenda for Interviews

The following general guidelines were used in the design process:

i) Emphasis was placed on feedback about success or failure of the existing curriculum.

ii) Especially in questionnaires, participants were asked to choose between concrete alternatives, rather than asked open-ended questions. For the first round the alternatives were formulated by the author using the relevant literature (Bear, 1974; Bugelski, 1971). For the second round those alternatives were used that were favoured or suggested by the participants during the first round.

iii) For larger amounts of data, numerical scoring was preferred in the questionnaires to allow averaging and easy comparisons.

iv) Special attention was given to specific comments/suggestions, relating to the particular respondent's case.

v) Published guidelines for the design of questionnaires (Anderson and Lusthaus, 1986) were taken into account.

vi) The questionnaires and interviews covered the main features of the course curriculum, namely objectives, content, process, and evaluation (=assessment). In general, the questionnaires were designed with an emphasis on transaction over transmission (= content). Of Fensham's (1977) three groups of curriculum dimensions (antecedents, transactions, outcomes) the antecedent dimensions were not taken into account in this project because the MBB programme prescribes virtually all courses for the student. By the third year the students' knowledge bases are very homogenous compared to other programmes. Of the transactional dimensions, the role of lectures does not apply to this course. The remaining dimensions were all taken into account. They fall into the categories of objectives (#6), process (#4, #5), and evaluation (#7). These categories are described in more detail below.

3.1. Design of the Questionnaires for the First Round of Data Gathering

In the design of the questionnaires a general pattern was devised at first which was then varied into different types for the representatives of the four commonplaces. This approach seemed reasonable because the objective was to mimick as much as possible the process of an actual deliberation, in which contributions from different directions on the same issue or question are to be synthesized into an overall image. The four types of questionnaires are included in the appendix.

The four types of questionnaires were not precisely congruent with the four commonplaces. I found it more effective to design the questionnaires in view of the general situation of the participant relative to the course. Type 1 was designed for the students, type 2 for graduate teaching assistants. Type 3 was designed for faculty members who had actively participated in the teaching of the course and/or the programme, mainly as advisors or counsellors. Type 4 was designed for faculty members largely unfamiliar with the course and/or the programme who could be considered as representing the milieu. Thus, only the questionnaire types 1 and 4 coincide with separate commonplaces. The commonplaces of subject matter and teacher are applicable to both types 2 and 3. For the benefit of those participants who were less familiar with the course or the programme, the following supplementary information was added: The type 3 and type 4 questionnaires contained the official course description of MB3A06, and the type 4 questionnaires also contained an outline of the MBB programme requirements.

Statistical studies (Adams and Gale, 1982) have shown an inverse relationship between questionnaire length and response rate. This imposes the necessity of limiting the length without condensing the content to an extent that would make the questionnaire too difficult. The questionnaires of the first round focussed on the following issues:

3.1.1. Learning objectives

Participants were asked to rank a number of learning objectives, in their order of general importance for science graduates as well as in their order of specific importance to a third year Molecular Biology laboratory course. Participants who were familiar with the course were also asked to specify the degree to which each objective was achieved by the course, and to which extent (and how) the achievement could be improved.

Mager (1962) defines an educational objective as fulfilling the following three requirements:

a) It describes what the learner will be doing when demonstrating that he/she has reached the objective.

b) It describes the important conditions under which the learner will demonstrate his/her competence.

c) It indicates how the learner will be evaluated, or what constitutes acceptable performance.

Of the three types of objectives, cognitive (knowledge), affective (attitudes), and psychomotor (skills), the former is generally considered most important by university faculty (Stark and coworkers, 1989). Affective learning objectives are the most difficult to formulate, to pursue, and to assess in science courses (Stice, 1976). Considering the makeup of the course and the difficulties associated with affective objectives (Beard, 1974) they had to rank secondary. Psychomotor objectives are achieved relatively easily in a laboratory course and were therefore not envisioned as very controversial. For these reasons, most of the learning objectives in the questionnaires were chosen to be of the cognitive type. For a third year course in this relatively demanding programme it seemed appropriate to emphasize the higher cognitive levels in Bloom's taxonomy (Bloom, 1956), especially since they appear to be generally underrepresented in university curricula (Stice, 1976). Rather than Bloom's (1956) general list, more specific lists of objectives for higher education were used (Beard, 1969; McGuire, 1963).

In the questionnaires, the participants were asked to rate the listed objectives. This approach is similar to the one taken by Short and Tomlinson (1979) in their evaluation of a programme in physiology and pharmacology.

3.1.2. Content

Participants were asked to rank a number of subject areas and areas of technical experience in their order of significance for a Molecular Biology graduate. Participants who were familiar with the subject material of the course were asked to make specific comments and suggestions.

3.1.3. Teaching Methods

The participants were asked to state their conception of how the work in a third year Molecular Biology laboratory course should be distributed, i.e.

- how much experimental work should ideally be performed individually by the student and how much should be performed jointly by the class or demonstrated by the instructor;

- how much of an assigned workload should be performed by students cooperatively versus individually;

- what fractions of the total workload should consist of theory, versus practice;

3.1.4. Student Evaluation

The participants were asked for their preferences among a list of alternative criteria and assignments that can contribute toward evaluation. For each item of their choice they were also asked to state whether the student's performance should best be evaluated by the student him/herself, by peers, or by the instructor. These choices seemed to be appropriate in the light of several reports that such alternative evaluation has great potential (Boud and Lublin, 1983; Whit, 1980; Boud, 1979).

3.2. Design of the Interview for the First Round of Data Gathering

The interview for the first round concentrated on the same main points as the questionnaires. In my questions I attempted to facilitate a freeflowing succession of ideas while making sure all main points were covered. The role of the interviewer can be described as observer-as-participant (Hannay and Seller, 1987; Gold, 1969), since it was limited to asking questions but attempted to stimulate by volunteering comments and suggestions.

All interviews were conducted using a printed list of agenda as rough guidelines but at the same time attempting not to cut short any contributions that the participant might volunteer. The common guidelines were chosen for two reasons: As a reminder for the interviewer to cover all important points and to ensure that the responses were comparable, i.e. that they were made to identical questions. For the latter reason the guidelines were not changed from one interview to the next even when the responses occasionally warranted such changes. The order of the questions, however, varied from one interview to the next.

All interviews were audiotaped to save notetaking and to collect verbatim quotes. They were subsequently transcribed, similar to the procedure used by Hannay and Seller (1988) for a deliberation.

3.3. Design of the Interviews for the Second Round of Data Gathering

Similar to the interviews for the first round, a written list of agenda was prepared. It focused on the following main points. The questions were varied somewhat to accommodate the varying amounts of experience in the participants. In addition to these main points, individual comments were brought up again for clarification. A total of four participants were interviewed in the second round. Two of them, the two students (C.B. and C.C.) were interviewed together. This resulted in a rather deliberative type of discussion.

3.3.1. Learning Objectives and Teaching Methodology: How can the most favoured objectives be taught more effectively in MB 3A06?

The relative effectiveness of a number of alternative teaching methods were discussed. The teaching methods suggested by Beard (1974), Cox and Kontiainen (1973), and Elton (1983) for specific objectives were used as suggestions. In addition, several specific changes that had been suggested were discussed for their potential in the pursuit of the learning objectives. Participants were invited to suggest any additional teaching methods which they might consider helpful.

3.3.2. Process

In order to put the responses from the first round into proper perspective, the participants were asked to give their own estimates on the following:

The balance between the amount of experimental work done as demonstration experiments by the instructor, jointly by the class, and independently by each student or lab group;

The balance between the amount of experimental work done by intellectual cooperation among students and as independently;

The balance between the amount of theory (lectures, reading) and practice (labwork, writing) in the assignments;

3.3.3. Student Evaluation

In response to the contributions from the first round, methods of oral student evaluation were discussed in their effectiveness and their benefit to instructors and students in the light of the favoured learning objectives. The relative merits of methods of self-evaluation, peer evaluation, and instructor- evaluation were also discussed.

4. The Second Round of Data Gathering

Participants for the second round were selected according to two criteria, their motivation and the commonplace they represented. A total of two students, the TA, and one faculty member participated in the second round. All participants are listed in Table 1.

To represent the data from questionnaires and interviews, they were grouped into four major categories, corresponding to the four commonplaces. Thus, the data were organized to reflect the conceptualizations of each commonplace by the participants. This format allowed for the identification of differences and common characteristics in the conceptualizations by the representatives of the four commonplaces. The juxtaposition then allowed conclusions on the nature of a hypothetical deliberation between these representatives.

Overall, the responses were of the following types, in order of decreasing frequency:

- Suggestions concerning innovations of the process (e.g. evaluation, weighting, time allotment, lab groups, etc.);
- Positive comments (reinforcements) on content and process;
- Negative constructive or nonconstructive comments;
- Thematic suggestions regarding content;

5. Data Analysis and the Evaluation Component

Most of the numerical data were derived from the rankings on the questionnaires of round one. Instructional Objectives were ranked from 1 to 5 in their importance, from 0 to 100 % in their achievement, and from 5 to 1 in their potential for improvement. For the first two categories the mean ranking was calculated for the students, teachers, milieu (MBB programme) and milieu (general). The averaging process took into account the overlap between the teaching and the milieu commonplaces; thus, the responses by S.T. contributed to both groups where applicable. The means were plotted as shown in figures 1 through 3. Because of the small sample sizes, the variation of rankings within a group was generally not quantitated unless there seemed to be a significant difference between groups. For the category of potential for improvement, the raw data were first converted to an inverse scale of 1 (no potential) through 5 (maximum potential). The converted rankings were then averaged and plotted as the other two categories. This conversion was done in order to render the graphical data representation more meaningful and clearer.

For student evaluation, different instruments were ranked from 1 (not appropriate) through 5 (very much appropriate). These data were averaged in the same way as the data on instructional objectives. In addition, the variations of the rankings of evaluation instruments were noted and incorporated into the graph. The variation of the data was not statistically quantitated since the sample sizes were very small.

Regarding teaching methodology, the four representatives of the general milieu (type 4 questionnaire, see appendix) were asked for their estimates of the following: the optimum time distribution on demonstrations, joint experiments and individual experiments; the fraction of written assignments to be carried out cooperatively versus individually; the balance between theory and practice over the total worktime. These estimates were for the most part discussed individually, but averages were taken into account where they seemed relevant. Additional numerical data, derived from the interviews, were estimates from the other commonplace representatives on the same parameters of teaching methodology. Since these data were again obtained from a very small number of persons, they were discussed individually as well.

Non-numerical data were analyzed with the objective of extracting a common consensus as well as collecting a spectrum of helpful individual views and suggestions. Consensus or common understandings were synthesized from various comments on the same issues. When there was obvious disagreement over an issue both sides were incorporated into this synthesis. The synthesis served as the basis of formulating recommendations.

Concrete recommendations for curriculum improvement were extracted from the summarized consensus. Other concrete recommendations (e.g. some specific teaching methods) were formulated from certain common understandings, taking into account the literature on teaching methodology and learning theory (Beard, 1974; Bugelski, 1971) and contextual considerations.

TABLE 1: The Participants in the Study, and Their Backgrounds

Students[1]

T.B.	
C.B.(*)	graduates from the 1989 class
C.C.(*)	
	plus 3 graduates from the 1989 class, 1 graduate from the 1990 class

Teachers and Subject Matter representatives

T.C.(*)	Ph.D. student in bacterial genetics, TA in 1990
S.B.	Professor in the Dept. of Biology, McMaster Univ. Programme Coordinator, Mol.Biol.and Biotech. Programme
L.P.(*)	Professor, Dept. of Biology, McMaster Univ.
T.F.	Assoc. Professor, Dept. of Biology, McMaster Univ.

Milieu and Subject Matter Representatives

S.T.	Chairman, Dept. of Biology, McMaster Univ.
R.S.	Professor, Dept. of Microbiology, Univ. of Guelph
D.H.	Professor, Dept. of Chemistry, McMaster Univ.
T.Co.	Medical Admissions Coordinator, McMaster Medical School

[1] Only the primary commonplace is listed for each representative. This should not be taken to mean that each participant only represented one commonplace.

(*) Persons who took part in both rounds of data gathering

FINDINGS I:

CONCEPTUALIZATION OF THE COMMONPLACES BY THE PARTICIPANTS

A deliberation on the curriculum design for MB3A06 would be, like all curriculum deliberations, shaped by the conceptualizations of the commonplaces by the participants. Any speculations on the possible shape and characteristics of the deliberation, therefore, require a thorough investigation of these conceptualizations. This chapter describes how the participants conceptualized the four commonplaces and how the conceptual differences and similarities might affect the potential deliberation.

1. THE STUDENT COMMONPLACE

A conceptualization of the student commonplace in an undergraduate programme involves many aspects, such as one's cultural background, experience, goals and aspirations, learning activities, personal growth, participation on curriculum development, and more. Since this study focused on the curriculum of one course, with the hope of arriving at some concrete curriculum recommendations, it was restricted to identifying the learning objectives and learning activities envisioned by the various participants. Input on the perceived importance of the student commonplace in curriculum development was also sought.

The following sections describe how the representatives of students, subject matter/teachers, and milieu conceptualize the student commonplace. It should be noted that the students in this programme represent a narrow subset of the general undergraduate population with respect to past performance level, goals and interests. Enrolment in this programme is restricted to students who have performed at first or second class standing in a defined set of prerequisite courses. The course itself is only open to students enrolled in the programme. Because of the uniqueness of this group of students, any attempt at generalization of the student commonplace using the available data must remain restricted mainly to this subgroup.

1.1. Learning Objectives and Their Achievement: What the Students Should Learn and How Well They Achieve

The participants were asked to rate the listed goals and objectives for the MBB programme. The numerical ratings are summarized in figure 1. It shows that the students (solid bars) named (in order of decreasing priority) thinking a problem through, independently designing simple experiments, and integrating information learned at different times as their foremeost objectives. Knowledge of the subject matter and oral presentation and communication skills ranked least in priority. There was little variation of this order among the individual responses; the choice of thinking a problem through as the most important objective was unanimous. One student explicitly emphasized the importance of independent thinking skills as a prerequisite for self-directed learning:

> When you're going into grad school you want to come out as a reasonably independent thinker, ...
> If .., you have the ability to work independently, then knowledge is just going to follow right along, ...
> knowledge is going to follow from independent thinking, and independent thinking is going to follow from interest (student interview 1, pp. 1, 2, 7).

Confirming the findings from the questionnaires, this student also stressed the importance of learning how to design experiments and learning how to write good lab reports:

> I think the one thing that I found was lacking in this programme - it's not understanding experiments or understanding that you must do controls, but I think it was designing experiments.
> Until I had marked a whole set of first year lab reports I realized I really wasn't sure what the heck people were looking for in lab reports.
> (student interview 1, pp. 2, 9).

The TA for the course gave a similar list. He gave maximum priority to thinking a problem through, application of theory, and designing experiments. He gave lower priority to laboratory skills, independent working ability, and the ability to integrate information. He differed from the students in his greater emphasis on knowledge and application of theory and lesser emphasis on integrating information. Because the TA's role does not differ essentially from a teacher's role these data were combined with those from the faculty members in figure 1 (strongly hatched bars). Henceforth the TA is included into the group named "teachers" unless specified otherwise.

Two faculty members who were familiar with the course valued theory even higher than the TA. Theory tied in second place with laboratory skills and independent work. Yet they, too, considered thinking a problem through and integrating information to be the most important objectives for students in this programme. Figure 1 shows that the teachers as a whole regarded thinking a problem through as the highest priority objective. Integrating information and knowing and applying theory tied in second place.

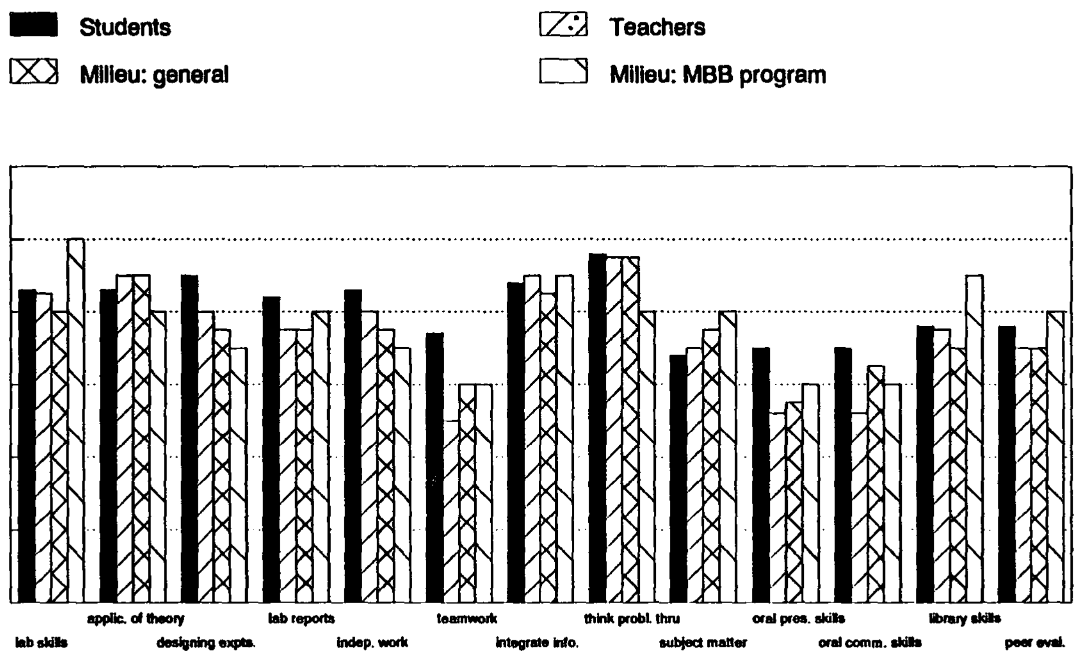
These first and second rankings were also shared by most of the representatives of the milieu, who were not familiar with this particular programme (figure 1, cross-hatched bars). Their responses referred to knowledge and skills which they considered important in prospective graduate students and technicians. However, it became apparent that the representative of the medical school preferred a different set of objectives than the other, more research-oriented milieu representatives. When asked specifically with respect to a programme in molecular biology the milieu representatives (lightly hatched bars) named laboratory skills, integrating information, and library skills as the most important objectives. In figure 1, this emerges as the only inconsistency from an otherwise rather homogenous rating pattern. Their ranking of laboratory skills was more than one standard deviation above the values given by the teachers and the students. Before one starts interpreting this discrepancy from the priorities of the students and the teachers it has to be noted that these milieu representatives were not familiar with this particular programme, which made them stand apart from the others as an experimental group.

An interesting finding was that teachers and most students agreed that the writing of good lab reports should not be an important objective. Proper use of a logbook and being able to evaluate one's data were considered much more important:

Figure 1: Ratings of Learning Objectives

Six students, two teachers and the TA, two faculty members familiar with the MBB programm, and two faculty members and one administrator not familiar with the course were consulted. They represented the particular commonplaces of the students, teachers, milieu (MBB program), and milieu (general) respectively. The participants in the first three groups were asked to rate the 13 listed learning objectives for the MB3A06 curriculum. The representatives of the milieu (general) were asked to rate the objectives for any third year laboratory course in molecular biology and biotechnology. Rating was done in five increments of importance as indicated. The ratings were averaged for each of the four groups.

Figure 1
Ratings of Learning Objectives



1=no, 2=minor, 3=average
4=major, 5=utmost importance

> I don't think lab reports are that useful - the format, the introduction, and all that. Because I think what we should be learning in third year actually is critical evaluation of your data. (student interview 2, p. 9)
>
> Writing up the results in a formal way is more akin to writing a paper than to doing the daily research in a laboratory using the logbook. If they learn how to do <u>that</u> [the latter] well, then this course I think would be a real benefit. (faculty interview, p. 8)
>
> That's important, to learn how to keep your results in a manner that you can recall. But at the same time I think as with the lab reports the students should be allowed the option of developing their own manner of keeping their lab book, rather than just being given one option. Because I think a way which works well for one person won't necessarily work well for another. (TA interview, p. 6)

These findings allow the following two tentative conclusions: First, the priorities in learning objectives for the programme are shared to a large extent across the commonplaces. Second, the emphasis placed by faculty on the teaching of subject content may not be as pronounced as has been assumed by many.

The participants were also questioned about achievement of instructional objectives, with respect to the students in MB3A06. Figure 2 summarizes the students' perceptions of their own and their peers' achievement of objectives (solid bars). Most of them ranged between 70 and 80 percent. The objectives are ordered according to their perceived priorities. The hatched bars represent the students' estimates of the potentials for improvement, i.e. the degree to which achievement in the course could be improved by appropriate modifications to the curriculum. Figure 3 summarizes the teacher's perceptions in the same manner. It shows that for most objectives, the teachers' perception of student achievement (solid bars) was lower than the students', in most categories by more than one standard deviation. The data also suggest that neither students nor teachers feel that their most important objectives are achieved very well (about 60 % and about 70 %, respectively). The two groups differ in their perceptions of the specific potentials for improvement: The students (figure 2) claim that some improvement in the course curriculum was possible to help them achieve their favoured objectives. The teachers (figure 3) appear somewhat less optimistic: Their estimates of potential for improvement (hatched bars) was lower than the students', in some cases significantly.

In summary, it can be surmised that a hypothetical deliberation may reach a rather quick consensus on general instructional objectives. Some disagreement may surface on the extents of student achievement and on the potential of the course for improvement, but the participants would likely have little trouble to agree on a number of broad goals to pursue in the subsequent deliberation. The deliberation is likely to then focus on which teaching methods and learning activities would be most suited for the pursuit of those goals. The participants' views on this subject are described in the following section.

1.2. Learning Activities: How Students Should Learn

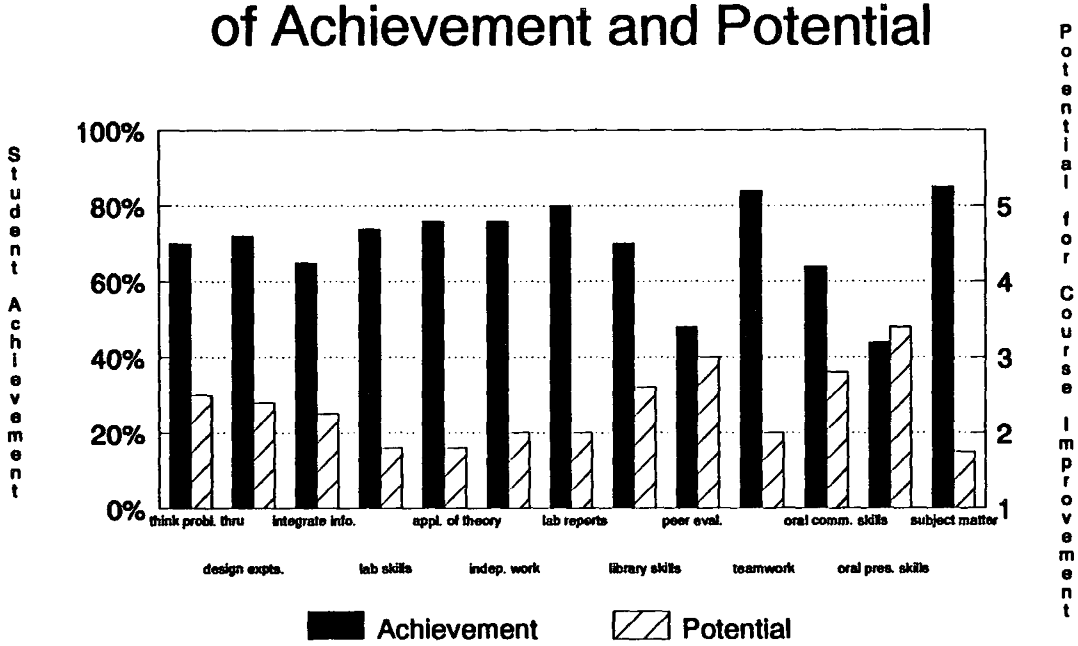
1.2.1. Intellectual Cooperation Versus Independent Work

The students expressed a slight preference for a lesser degree of intellectual cooperation than was evident in MB3A06 in its present form. In this course, approximately 25 - 30 % of the written assignments (i.e., lab reports) were prepared in cooperation within lab groups. In addition, much of the daily laboratory chores were shared:

Figure 2: Students' Perception of Achievement and Potential

The six students were asked to estimate student achievement of the 13 learning objectives in MB3A06, as a percentage of a possible maximum. They were also asked to estimate the potential to which the achievement in each objective could be improved by changes in the curriculum. This estimate was done in five increments as indicated on the right ordinate. The plotted values represent the averages. In this diagram, the objectives are listed in decreasing priority from left to right. Priorities were determined as described in figure 1.

Figure 2
STUDENTS' Perception of Achievement and Potential

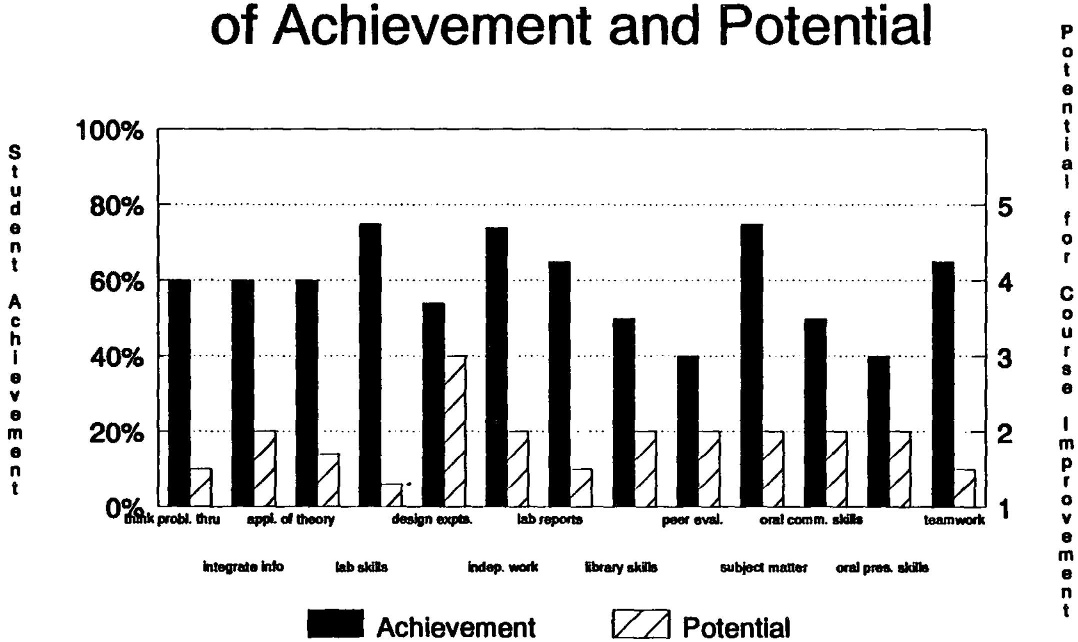


Priority decreases from left to right.
Potential for course improvement:
1=no, 2=some, 3=considerable, 4=massive, 5=any change would probably cause improvement

Figure 3: Teacher's Perception of Achievement and Potential

The three teachers were asked to estimate student achievement of the 13 learning objectives in MB3A06, as described in figure 2. They were also asked about the potentials for improvement as described in figure 2. The objective priorities again decrease from left to right.

Figure 3
TEACHERS' Perception of Achievement and Potential



Priority decreases from left to right.
Potential for course improvement:
1=no, 2=some, 3=considerable, 4=massive, 5=any change would probably cause improvement

> ...sometimes we lumped several groups together and there were maybe two experiments done by four groups or something like that. Especially towards the end when we did plasmid preps or something. Yeah, somebody would come in and do everybody's.
> [when asked about how much of the assignments were carried out in cooperation:]
> 15 % is close but I still think there was more cooperation. Yeah, especially with your partner. It would probably be about 25 % . (student interview 2, p. 12)

One student explained that while they did welcome the excitement and challenge of open-ended, independent laboratory work, some might not live up to the reponsibility if too little structure were provided:

> Some people would really get into it and do a lot of work. Other people would just kind of lose interest, that would probably happen. (student interview 2, p. 1)

Self criticism like this surfaced frequently with the students; this helps to qualify them as valuable contributors in a curriculum development process. The need for external motivators was expressed repeatedly in different contexts by several students. They also advocated the concept of student experts as providing enough incentive to encourage independent library work:

> [They would] read up on the yeast genetics and then we've got somebody who knows it. I think you'd have to provide at the beginning like a reading list. To get people started, so they know where they should be looking. Yeah, I think it would work. (student interview 2, p. 6)

Among the teachers, the TA advocated a lesser degree of cooperation. The students' divergent interests and abilities would create a basis for more independent learning activities:

> [The course] might be improved by giving it a bit less direction and by giving the students an overall goal to attain at the end and by leaving more of the actual work to the students.
> ..obviously the students don't have the background, they don't understand how to solve certain problems yet, but it should still be up to the student to come to the instructor, rather than the instructor coming to the student. (TA interview, pp. 1 - 2)

The TA also cited evidence that the students were more highly motivated when working independently on open-ended problems:

> I noticed that in the lab reports. I mean they really put a lot of effort into that part. (TA interview, p. 3)

This contrasts somewhat with the students' views above, that external motivation was indispensable. It seems that the TA had more confidence in the independent working abilities of the students than did the students themselves. The other teachers tended to agree with the majority of the students in that 25 % of cooperation was enough and probably appropriate for students in a course like MB3A06.

The representatives of the milieu differed widely in their views on cooperation among students. Their estimates of the optimal percentages of assignments carried out in cooperation ranged from 10 % to 70 %. The heterogeneity within the commonplace of the milieu will be discussed in section 4.3.

Notwithstanding the heterogeneity among the milieu representatives it can be concluded that on average the students are generally regarded as capable of independent work. The amount of independent work in this course, however, was limited by contextual factors. The students perceived these to be logistics of monitoring, limited resources, and their conditioned dependence on external motivators. They were also concerned about unequal workloads. The faculty named subject matter considerations as the main limiting factor:

> ...I think that's the problem, in that there are technical skills, things that have to be learned using machinery, and you can't just sort of turn the students loose over the whole year, because they are incapable of using the tools. If you spend too much time teaching then how to use the tools ... I mean trying to integrate teaching of the tools and the independence of running through a lab is logistically a little tricky. (faculty interview, p. 6)

1.2.2. Learning Through Discussions

Students as well as teachers regarded most students well capable of actively participating and learning in discussions. Moreover, the importance of oral presentations was recognized by all respondents. The problem of domination by certain students was also recognized by all but was not considered prohibitive:

> I think discussing results is a useful exercise, everybody discussing experiments to start as I said would probably tend to be dominated. Discussing data that they've already got and trying to put a picture on it could probably help some people to do a much better job with the data. (faculty interview, p. 7)

> ... if everybody understood what was going on, then you could have people come up with ideas and stuff like that, and you could have discussions. But if people don't know what's going on and don't have a great idea, then you're only going to get a small group of people talking and it's probably not going to be very helpful. (student interview 2, p. 2)

Both groups recognized the limits of this activity, namely that the topics and scopes of the discussions should be kept appropriate to the abilities of the average third year student. Students' results and research literature were considered suitable topics by students and teachers. They also advocated the use of student experts in discussions. Experimental design was considered by one teacher too difficult and prone to domination (faculty interview 2, p. 7, as cited above), while the students were less concerned with difficulty. Instead, the students named shyness as a hindering circumstance, which could however be counteracted by appropriate organizational measures such as student pairs and an informal setting. Representatives of the milieu were not consulted on this issue because they were not familiar with this particular student population.

1.2.3. Learning from Research Literature

The interviews showed students and teachers agreeing that the students in MB3A06 were capable of learning from research articles. Certain restrictions were also recognized. A faculty member emphasized that the articles would have to be "carefully chosen, easy, and of key importance to the field" (comment on questionnaire). The TA and the students emphasized procedural restrictions:

> That was probably one of the best things that I learned in third year, how to read a paper.
> I think it's important that the TA went over it. He didn't ask you [to go over it], because I think that would really have cut down on the [number of] people in the tutorial.
> I don't think students have enough knowledge or guts to do it [present research papers] in third year. I didn't understand much of what I read in third year. (student interview 2, pp. 4, 5)
>
> ..I'm not sure if presentations of research papers would be valuable. But maybe incorporating some actual research papers into the lab manual ... and show[ing] them how the methods can actually be used. (TA interview, p. 4)

The interviewed faculty member suggested to assign selected papers, perhaps for individual oral presentations. The students agreed with the potential benefit of involving more research literature but were quite opposed to the idea of student presentations:

> We did that in fourth year, and that was brutal.
> I think there'd be a lot of trips to the TA. (student interview 2, p. 5)
>
> I think that in third year I benefitted not a whole lot from those paper reading things. But in fourth year when you had to read them, and you had to do it yourself, that was when I taught myself how to read them. (student interview 2, p. 11)

This indicates a certain difference between teacher and students in the perception of analytical ability of the students in MB3A06.

1.2.4. Learning by Becoming Interested

Neither teachers nor students considered lack of interest a problem in this course. Nor did they express much confidence in interest-nurturing measures as part of the curriculum, not even towards alleviating some of the widespread procrastination. One teacher noted the pitfalls of misguided motivation:

> ...even in fourth year undergraduate courses students are coming in who take about three or four months to recognize that what they're doing is one little project. Because when they don't get that realization then the project never really gets done because they can't focus on this little bit. They're always looking somewhere for the big picture which is too big.
> .. an unrealistic motivation ... could be tempered with realism ... You can hope to attain the stars but you have to go to the moon first. (faculty interview, p. 5)

The students and the TA described personal experiences to point out that intitial interest in a discipline was often acquired outside of the formal setting of a course, long before the third year of university.

> I think it also depends on if the student wants to be there in the first place because in this case I would think that most of the students are in the programme because they want to be in the programme, because they're interested in it. It's not a course that's required of somebody who might not be interested in it. (TA interview, p. 7)

The consensus emerged that there was no need for the MB3A06 curriculum to particularly concern itself with affective objectives.

1.2.5. Participation in Student Evaluation

Participation of students in their evaluation can take the form of self- or peer evaluation. Both forms require a certain maturity and objectivity. The students considered each other to be quite capable of participating in their evaluation. The majority (three of five) suggested peer evaluation as a reasonable option with some of the evaluation instruments used. They considered peer evaluation unsuitable to evaluate a student's general participation. Self evaluation was suggested by a minority (two of six). One student expressed his scepticism with self evaluation as follows:

> Self evaluation is tough. Because there is no precedent for it at all in almost any of the education systems we've been involved in.
> I may think this, but in reality, I'll say OK, well you know you're not very strong there. So it's like two voices, but it's very hard to vocalize that sort of thing. It's very hard to own up to it, as opposed to just the thinking. So self evaluation,

> which I think is good, is something that you'd really have to phase in gradually. (student interview 1, p. 13)

The teachers were more reserved in their views. The TA questioned the value of any student participation in evaluation in a class small enough to allow for one-on-one contact of each student with the instructor. The faculty members generally agreed with this view but admitted the possibility of student participation with specific evaluation instruments such as oral presentations or lab reports. They did not agree on any specific instrument as particularly suitable for student participation.

The milieu representatives were very much divided on this issue. Their suggestions ranged from peer evaluation as the major overall method (suggested by the medical school representative) to omitting student participation altogether (suggested by a faculty member).

1.3. Participation of Students in Curriculum Development

The responses from the students indicated enthusiasm about any opportunity to become involved in curriculum development. However, the fact that only six of thirteen students responded may indicate that this attitude is not shared by all. The teachers and most milieu representatives were rather reserved about student participation in curriculum development. Their lack of confidence in student maturity and altruism is also reflected in their disapproving view of students participating in their evaluation. In this regard there appears a distinct discrepancy in the ways the student commonplace is conceptualized by the students themselves and by representatives of the other commonplaces. This discrepancy might also affect the way the student commonplace would be treated by the participants in a deliberation.

One reason for the enthusiasm of the responding students could lie in their perceptions of the potential of curriculum revision. Generally, the questionnaires and interviews suggest that the students see more room for improvement than the TA, who sees more room for improvement than the faculty. The significance of this might lie in the differences in teaching experience, or in different degrees of being bound into the existing structure, or it could be simply a matter of age. Although some of the students have worked as TAs in introducory courses their overall notions of what can be actually achieved in a classroom or laboratory situation is probably much less realistic than that of the TA. The same relationship holds when comparing the TA with faculty members who have taught at the university for several decades.

2. THE SUBJECT MATTER COMMONPLACE

In this study, it seemed difficult to identify any subject matter representatives who did not also represent one of the other commonplaces. Subject matter considerations were most frequently mentioned by the teachers and least frequently by the representatives of the milieu, who were not familiar with MB3A06. The most striking difference between secondary and postsecondary courses is the general absence at university of official compilations of specific instructional objectives. This allows for considerable flexibility in course content and course organization, and it enables the instructor to adapt the curriculum to the needs of a particular group of students. On the other hand, the many benefits associated with a list of instructional objectives are lost. Naturally the subject matter priorities for a given course vary greatly between instructors, and this also became evident in this study in the varied suggestions for course content. However, subject matter considerations go beyond the process of choosing a list of topics as course content. For Mb3A06, different views were evident on topics, lab techniques versus applications, comprehensiveness versus specialization, and theory versus practice.

In the last two years the course consisted of transposon mutagenesis of bacteria and subsequent mutant analysis, restriction mapping, and yeast transformation. Except for the yeast part, these experiments formed a continuous sequence along a particular route of investigation. In the years before that, the course featured a wider variety of unconnected experiments in molecular biology techniques like Northern Blots, in vitro translation, and protein electrophoresis.

This change in curriculum went deeper than the obvious switch in subject matter. The curriculum emphasis was changed from a comprehensive survey of techniques and the underlying theory to a more self-guided investigation within a much narrower scope of topics, applying a smaller number of techniques.

2.1. Topical Content

The students expressed little subject matter preference. As outlined in section 1.2.4., they entered the course with a keen interest in molecular biology and they appeared ready to absorb any selection of topics in any order. Two students expressed their appreciation of the fact that the course uses microbes rather than higher organisms or cell cultures.

In contrast, the teachers differed greatly in their views and topic preferences:

> Experiments in microbial genetics introduce the student to a unique way of thinking and approaching problems. It also provides the most direct link between genetics and physiology. (TA, comment on questionnaire)
>
> There is a need in the programme for microbial genetics experiments as the students get none in any other course. (faculty member, comment on questionnaire)
>
> I think a fundamental comprehension of the principal techniques in common use in the field is very important. If this is achieved while learning how to manipulate bacteria and viruses and plasmids, then so much the better. (faculty member, comment on questionnaire)
>
> The course is molecular biology, not microbiology. The earlier approach [with its focus on techniques] was more appropriate and beneficial to students. (faculty member, comment on questionnaire)

The two responding representatives of the milieu, not being familiar with the course, differed most widely in their topic preferences for a third year laboratory curriculum in molecular biology. Of 12 subject areas only two (cell physiology/metabolism and mycology) were chosen by both as indispensable. This illustrates how outside the limits of a particular course the subject matter commonplace becomes an ill-defined, subjective entity. Both representatives regarded laboratory experience with bacteria as indispensable for students.

2.2. Laboratory Techniques Versus Applications

The students were almost all in favour of the current format of a series of techniques applied to a concrete project over the former format of a straight methodology survey. Two explained that the new version taught them to think and to follow problems through. Another claimed that the new form more realistically illustrates the research scene. Two students simply liked the "continuity", and two pointed out correctly that most of the former content is now taught in fourth year. Some heterogeneity in their views of the subject matter, as well as differences compared to the teachers' views, were also noted:

> ...because it's a third level course I don't think you have to have the emphasis necessarily on techniques. They're going to get that, or they may have already had it working in labs, they're going to have to develop those things in a thesis, and they're going to do the Molecular Bio Lab in fourth year, which is just hard techniques ... So maybe you could use this course more in that direction, you know, something that really gets people feeling very comfortable in a lab environment, and feeling creative. (student interview 1, pp. 7, 8)

> The outcome of one of our labs was connected to the next one. That makes a huge difference over the rest of the stuff that we've been dealing with. And that's very important, I think, you know, finally here we were doing something which seemed to have a point. That's the thing with the 3L6 labs [a straight techniques course]. They'd be fine if they were integrated into one problem or something like that, but they seem very pointless just on their own. (student interview 1, p. 8)

> It was good when we each got our own mutants because then you kind of felt you're no longer following a recipe, you're pursuing <u>your</u> mutant. That's where it broke off and became really interesting. (student interview 2, p. 4)

Most of the teachers favoured the change in curriculum.

> I believe it is a positive change because the course should be more than just a techniques course. (TA, comment on questionnaire)

However, some reservations were also noticeable from the teachers:

> We had a problem when we had the techniques lab which was sort of a predecessor to this many years ago. We tried in the first term to teach a few pieces of equipment ... So they'd learn to use techniques, and then in the second term they had a short project, and they were supposed to do their experiment at their own time using these techniques. ... the second term, where they were sort of left on their own, I'm not sure how successful that was. It still needed a lot of guidance, a lot of help.
> ...you could keep encouraging them by telling them the technique they were learning they were going to apply, so you kept that hope alive, that something was going to come. I don't know how you escape the drudgery of learning how to use something. ... You might teach one piece of equipment with one project, but you couldn't do four or five different pieces of equipment or different techniques and integrate them successfully, at least I don't think so. (faculty interview, pp. 5, 6)
>
> I like the integration of experiments, i.e. the progressive nature of problems. (faculty member, comment on questionnaire)

While the preference for the new format is obvious, these comments illustrate again the idiosynchratic nature of the subject matter commonplace. They also show that sometimes a compromise between two opposite views is hard to find, as between a "techniques advocate" and a "project advocate".

It seems that the teachers tended to view the subject matter of MB3A06 more in its context with other courses in the programme, whereas the students tended to view the course and its subject matter more as an isolated entity. The underlying reasons may be differences in learning objectives, in the concepts of what learning the subject matter should accomplish in the student. Students who are either still in the programme or have just graduated from it may not yet have the necessary perspective to view the subject matter taught in a course or programme in the context of the entire academic discipline. Thus they may more readily subscribe to the view, "whatever I don't learn in this course I will learn somewhere else". University instructors, concerned with curriculum planning at various levels, obviously cannot afford this simplification. In this context it was noticed that the students seemed to regard the subject matter as something to experience, whereas the teachers tended to regard it as something to inculcate. This crucial difference in perspectives constrasts somewhat with the general agreement over learning objectives. The difference indicates a division over the means toward common ends which could be deeper than the findings on learning activities (section 1.2.) suggested.

2.3. Comprehensiveness Versus Specialization

> It is better for students to tackle a few lab exercises and do them well, than to survey a lot of techniques rather superficially. (faculty member, comment on questionnaire)

The issue of the degree of comprehensiveness of the subject matter was not directly addressed in the questionnaires and interviews. Yet it cannot be entirely avoided since a switch to a more project-oriented curriculum necessarily narrows the variety of techniques covered, as explained by the interviewed faculty member (faculty interview, p. 6, cited in section 2.2.). Since the majority of the faculty and students expressed their support of the change towards a more project-oriented curriculum, it must be assumed that they are also not opposed to the resulting increase in specialized subject matter covered, at the expense of comprehensiveness. One of six responding students felt that the change had not gone far enough and called for inclusion of more primary literature into the subject matter of the MBB programme.

2.4. Theory Versus Practice

The subject matter in MB3A06 can be classified into theory (lectures and reading) and practice (lab work, writing, discussions). In the current format, the subject matter in the course is distributed as shown in the table below, column "MB3A06 in its current form". The numbers represent the percent of total worktime and were determined by consensus among teachers and students. This distribution represents the subject matter as containing 20 % theory.

	MB3A06 in its current form	preferences stated by milieu reps.
Background lectures	5	10 - 40
Background reading	15	10 - 20
Experiments	55	25 - 40
Lab report writing	20	5 - 10
Lab meetings and discussions	5	5 - 30

The representatives of the milieu, when consulted about their views about an optimal subject matter distribution in a course like MB3A06, gave a range of numbers which is shown in the second column. Obviously the subject matter in its present format does not conform well to the ideal as conceptualized by the representatives of the milieu. Most notably, it includes a much smaller fraction of lectures and a much larger fraction of writing. The distributions suggested by the milieu representatives contain as much as 20 - 60 % theory. The wide ranges of numbers again reflect a heterogeneity in conceptualization among the milieu representatives, as was noted earlier.

In contrast, three of four responding students considered the subject matter of the course well balanced. The remaining student felt that theory was underrepresented. He pointed out that towards the end of the course the heavy load of lab report assignments prevented them from pursuing more in-depth studies of the theoretical background. The students were also consulted about the subject matter of the MBB programme in general. Of six students responding on that issue, three considered the subject matter appropriately balanced in theory and practice. Two students felt that while the course was balanced, the programme as a whole contained too much theory and not enough technique. Despite this heterogeneity it can be concluded that the students in general conceptualized the subject matter as more practice-oriented as did the milieu representatives.

The teachers generally agreed with the balance of the course's subject matter, but two of them called for a reconceptualization of theory to make it more relevant to the students' experimental work:

> I think that the theory should be learned from, and directly related to, the experiments that are performed. In this way the relevance of the theory can be truly appreciated. (TA, comment on questionnaire)

On the subject matter of the MBB programme, the teachers seemed as widely divided as the milieu representatives. Of four responding faculty members, one considered the subject matter of the MBB programme well balanced, two called for more practice, and one called for more theory. This suggests that even within the framework of a specific programme the subject matter is conceptualized by the teachers in a highly idiosynchratic manner. On the level of this specific course, however, the teachers were quite in agreement with the students' conceptualization.

3. THE TEACHER COMMONPLACE

When characterizing how the commonplace of the teacher is conceptualized, a number of roles have to be taken into account that the teacher plays inside and outside of the classroom. The teacher's most important and complex role is probably facilitator of learning. Other indispensible roles include evaluator and curriculum designer. The following description refers to these roles in turn.

3.1. The Teacher As Facilitator For Learning

The learning of content and skills will only be facilitated adequately if the students are surrounded by a suitable learning environment. The shaping of that environment is largely the responsibility of the teacher. The exact nature of that environment depends on many interdependent variables such as instructional objectives, resources, physical conditions, cultural backgrounds, and particularities of the students and the teacher.

For MB3A06, many of the characteristics of a desirable learning environment have already been described in connection with the student commonplace. One aspect which remains to be illuminated is the manner in which the teacher is expected to facilitate a desired learning environment. This includes amounts of demonstrations, prominence in the laboratory and in discussions, design of the lab manual, and amounts of preparations.

3.1.1. Demonstrating Experiments

Every lab course has to be balanced between the amounts of experimental work done as demonstration experiments by the teacher, jointly by the class, and independently by each student or lab group.

The TA, as well as the students, agreed in their estimates on the extent to which experiments were performed as demonstrations in MB3A06. Their estimate is shown in the table below, as percent laboratory time spent on each activity:

	MB3A06 in its current form	preferences stated by milieu reps.
Demonstrations by the teacher	20	10 - 15
Experiments done jointly by the class	30	10 - 20
Experiments done individually or in groups	50	70 - 80

The three representatives of the milieu were asked to state the optimal time distribution for a third year lab course in molecular biology. Their ranges of distributions, unusually homogeneous, are also shown in the table. This indicates that the representatives of the milieu do not perceive the teacher predominantly as demonstrator. In contrast, the students in MB3A06 considered the 20 % demonstrations quite appropriate. One student suggested to emphasize demonstrations early in the course and to phase them out toward the end, in favour of individual experimental work.

The three faculty members who were familiar with the course also considered the experiments appropriately balanced between demonstrations and hands-on work. It is possible that the particular nature of MB3A06 leads to a greater emphasis on the teacher's role as a demonstrator than is conceptualized by the milieu representatives. Obviously a compromise has to be found between this view and the high emphasis on individual experimental work favoured by the majority of students and teachers (section 1.2.1.).

A very different type of demonstration, teaching how to write a good lab report, was considered important by one student:

> I am a big proponent of learning by example. So you should probably tie that sort of thing into what the grad student would be telling the students. Perhaps a section on it in the manual might [also] be good ... (student interview 1, p. 9)

3.1.2. Prominence of the Teacher

It should be noted that the role of teacher in MB3A06 was assumed intermittently by the TA (a Ph.D. candidate), a sessional lecturer (myself), and two members of the faculty. These differences in academic standing, professional experience, as well as age differences probably led to different levels of authority in the eyes of the students. A conceptualization of the teacher commonplace by the students and the teachers, which is based on the available data necessarily represents the result of an averaging process over this heterogeneity.

The TA regarded the role of the teacher as one of relatively low profile. When asked how to best teach the students to think independently, he states,

> I think it is something you have to develop yourself. I don't think it's really something that can be taught. You have to be put in a certain situation and learn how to deal with that situation.
> The instructor can provide the appropriate situation, I guess. That's what the role of the instructor should be in that case. .. It would be the presentation of problems and perhaps different suggested alternatives for solving the problem, but leaving it up to the student which route is followed. (TA interview, p. 1)
>
> .. it is important for the student to recognize the problem from the beginning, because I think often the student won't actually realize that a certain thing is a problem, I think they're just told. But if they actually experience that, then they'll retain that.
> .. it should still be up to the student to come to the instructor [for help], rather than the instructor coming to the student. (TA interview, p. 2)

Clearly this concept of the teacher's role goes beyond a low profile. Striking the appropriate amount of student guidance and setting up appropriate instructional situations is the central problem in facilitating experiential learning, and the TA is aware of that. One faculty member points out the problem of adapting one common learning environment to a heterogeneous group of learners:

> .. very often the people who had good grades don't like the environment of a situation where suddenly they are not being told what to do. They are being asked what to do. .. Some straight-A students in courses obviously are not straight-A students in the laboratory if they are graded by some sort of plot-grade. And there are other people who really have that but maybe have not shown it in the normal lecture situation, but have persisted or they wouldn't have made it here. And when put in the lab it becomes clear after a few months that this is exactly what they've always wanted to do. (faculty interview, p. 2)

He also emphasized the importance of repetition and descriptive science in teaching problem solving. On the teacher's side this means waiting in the wings, ready to provide additional structure or encouragement when necessary. In a lab course like MB3A06, therefore, the teacher is conceptualized by these respondents more as an observer, who only on occasion and in response to individual needs assumes an active role. In contrast, the students seemed to have less confidence in their abilities to perform well in experiential learning, as pointed out in section 1.2.1. This means that the students' concept of the teacher involves a more active role, providing more structure and guidance than envisioned by the teachers themselves.

The role of the teacher is conceptualized differently in the context of class discussions. The students emphasized the importance of an active steering of class discussion by frequent intervention by the teacher:

> I think if you ask people direct questions, like ... what would we do in this step, or why are we doing this, or can you explain this to us, man oh man, I wouldn't want to be caught not knowing anything. Because you're making a fool of yourself; the professor isn't doing anything to you, he's just asking you a straight question. (student interview 2, p. 3)

Through such intensive discussions, the teacher is supposed to instill a thought process, which normally only takes place when the lab report is being written, at a much earlier time, namely prior to the actual experiment. While the vast majority of students called for more such discussions in the framework of formal lab meetings, one student expressed his/her concern about too much discussion limiting the encouragement of independent thinking.

The students also expected the teacher to recognize in his chairing of class discussions the bounds of the students' horizon. The teacher should closely delimit the grounds of a class discussion. A discussion of research proposals, for instance, would be futile and counterproductive. A discussion of procedures used and results obtained could be very valuable, while a discussion of others' results in a wider context would quickly lose the majority of the class.

The teachers did not quite agree with this rigorous limitation. The TA argued repeatedly for a greater prominence of research literature in the course. This would necessarily also extend into class discussions. On the other hand, the findings described in section 2.4. clearly show that the teachers did not place much importance on lecturing in this course. Whether the teacher would be capable to maintain a true discussion on demanding topics like research literature must remain an open question, but the teachers appeared certainly more confident of their own abilities in this respect than did the students.

3.1.3. Designing the Lab Manual

One duty of the teacher which is far removed from the laboratory is the annual re-editing of the lab manual. The students obviously consider this an important component in their concept of the teacher's role, because they made various suggestions for revising the manual. Some of these suggestions are discussed in the following chapter.

The TA refers to manual revision in a manner similar to the students. In contrast, the other teachers did not refer to it in their comments, nor did the representatives of the milieu.

3.1.4. Preparing Materials

During the last two years the bulk of the preparation work, such as media preparation, was increasingly taken over by the departmental technicians. However, two considerations argue against a complete separation of the teacher from the reponsibility for preparatory work. First, the procedures for the preparation of some of the materials, such as enzyme solutions, require considerable experience, and others have to be prepared immediately prior to the experiment. Secondly, preparing some materials from "scratch" can be a valuable learning experience for the student. A conceptualization of the teacher as facilitator therefore has to take these considerations into account.

The available data show little evidence that any of the representatives reflected much on this aspect. The students proved quite ready to share preparatory tasks with the teacher and the TA on a volunteer basis. One student mentioned the amount of preparatory work as a limitation to individualized laboratory assignments for students. Repeated allusions by the TA and students to a greater orientation of the course experiments towards research only implicitly recognized the need for a greater involvement of students in preparatory work.

A slightly different kind of preparatory work involves the teacher as motivator, providing a motivating learning environment. As discussed in section 1.2.4., both teachers and students saw little need for special efforts toward student motivation.

3.2. The Teacher As Evaluator

The concept of the teacher as evaluator obviously gains in weight as the alternatives to teacher-mediated evaluation, peer- and self evaluation, are disregarded. The data described in section 1.2.5. suggest that the teachers perceive the teacher as virtually the sole evaluator, the students perceive this role of the teacher as less prominent, while the milieu representatives were divided as usual.

Student evaluation in MB3A06 involved a considerable variety of evaluation instruments, and even more could conceivably be implemented. The participants were asked to rate a number of possible evaluation instruments for their appropriateness for MB3A06. The results are shown in figure 4.

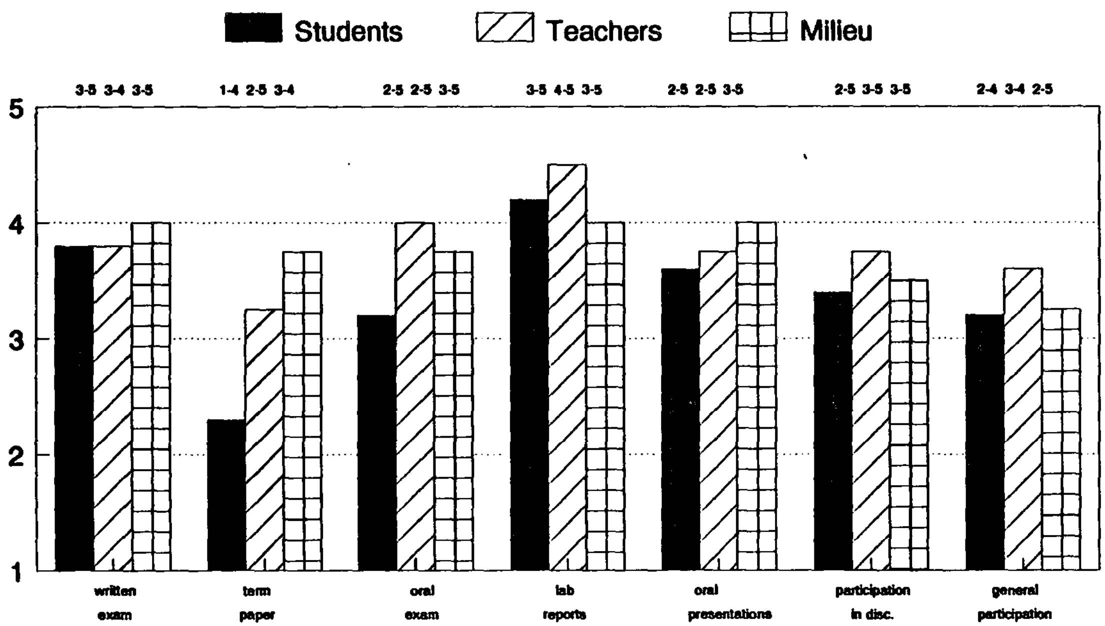
The graph shows that the students, teachers and the milieu representatives generally agreed in their preferences for certain evaluation instruments. All three groups chose lab reports and the written exam as highly appropriate for the course. Besides this general consensus, the graph shows specific discrepancies where one group disagrees from the other two. For instance, the teachers favoured an oral exam more than the other two groups.

Figure 4 also shows that the students are decidedly opposed to the term paper as evaluation instrument in MB3A06, much more so than the other two groups. In fact, there is no indication that the other two groups are as decidedly opposed to any of the listed instruments. This view of the students may stem from their stronger preference for a more practical, research-oriented curriculum. They probably experienced all too often in other courses that a term paper was quite detached from the main topics of the course.

Figure 4: Ratings of Evaluation Instruments

The six students, three teachers, and four milieu representatives were asked to rate the applicability of seven different evaluation instruments to evaluation in MB3A06. The ratings were done in 5 increments as indicated and averaged. The numbers above each bar describe the range of individual ratings.

Figure 4
Ratings of Evaluation Instruments



1=not appropriate, 2=not very applicable
3=somewhat useful, 4=quite useful,
5=very much appropriate

> Term papers - I don't think a term paper is necessarily really applicable to this course. It would be very difficult to integrate it. Unless you had like a total lab writeup, but then you'd be bound to just get low quality stuff, simply because of the way things shake out at the end of the year. (student interview 1, p. 12)

The choices of the milieu representatives should be viewed in a slightly special light since they alone were not directly familiar with the course. However, they had been supplied with course outlines and other information on the programme. The milieu representatives preferred the written exam over any other alternative. Given the unusual emphasis on laboratory activities in MB3A06 it seems understandable that neither students nor teachers share this preference for summative evaluation. The evaluator is conceptualized by them as an active participant in the laboratory activities who can supply frequent feedback through formative evaluation.

Along the top of the graph in figure 4 are shown the ranges of ratings for each instrument and each commonplace. They indicate that the ratings by the milieu representatives showed less variation than the ratings by the others. There is little indication of heterogenity among the milieu representatives, in contrast to many other instances in this study. Their concepts of the evaluator appear to be rather similar and unaffected by their heterogeneous views on other aspects of the curriculum.

Oral evaluation instruments were preferred by majorities across the commonplaces, with the students consistently being less enthusiastic than the other two groups.

> Oral presentations are nice - very nerve racking for a lot of people. A lot of people have real problems talking in front of other people. But by sparing them an oral presentation you're not doing them a favour, certainly. (student interview 1, p. 12)

Interestingly, the TA rated oral exams and oral presentations less appropriate than the other teachers, which means he sided with the majority of the students. The general consensus on oral evaluation again indicates that the concept of the evaluator contains a strong element of active participation, of formative evaluation through discussions and conversations about aspects of the lab experiments. The lesser preference from the students and the TA may stem from a feeling of inadequacy on the part of the student. Since oral evaluation often elevates the student to the level of equal conversation partner to the teacher, it requires a considerable measure of self confidence in the student. Different levels of self confidence may be the reason for the particularly wide ranges of ratings of oral evaluation instruments by the students. None of the participants rejected outright the common instrument of "general participation", which is often a rather subjective evaluation of a student's oral prominence.

In summary, we can use the data to construct the following concepts of the teacher as evaluator: The students conceptualize the evaluator as taking part in the laboratory work through frequent questioning and involving students in conversations and discussions about their work. Such evaluation should be entirely formative and mainly for the purpose of providing feedback to the student. The evaluation should be done by the teacher who spent the most time with the class, which is usually the TA. There was considerable opposition to the idea of the teacher actually grading participation in discussions. Several students also suggested to include oral presentations into the evaluation, preferably by students presenting their own results. Some of the students, on the other hand, felt reluctant to enter into such conversations with the teacher and therefore prefered the safe distance inherent in written evaluation instruments. All students considered the evaluation of written reports indispensable, but again in a formative rather than summative style.

> Written examinations, I guess you have to accept them. Oral examinations are ideal, I think, but very difficult in practice to do. It's tough to be an oral examiner, because you don't want to kill the student, just sort of sit there and let them sweat when they don't know an answer, but on the other hand you don't want to give them the answers either. And some TAs go to opposite extremes like that. (student interview 1, p. 12)

It was recommended by the students to assign as many lab reports as possible as early as possible in the term in order to make that component of the evaluation as formative as possible. The evaluator should be more attentive of the way in which the students interpret their data and how critically they work with them, rather than how accurately the procedure was perfomed. Evaluation of the laboratory work was considered more important than any other evaluation, including performance in the final exam. Frequent "feedback" was demanded by many students as absolutely essential:

> I really think if you establish a really concrete framework for the direction you want the course to go in I think the TA is simply an extension of that.
> I think if you want to be a good TA you've really got to appear to be interested in making the lab interesting and successful. You've got to be there for the students, they have to believe that you're there for them all the time, even if you're not. And to that end I think a lot of written comments on labs are really necessary. I know some TAs who say, look, you know, I told them what I wanted in the lab at the beginning of the lab, if they don't give it to me that's fine. This is the mark they get. But students really need to have stuff emphasized. (student interview 1, p. 16)

The students also emphasized that the evaluator should make public his marking procedures and keys, and the evaluation should be valid with respect to the curriculum. The more detailed a marking scheme was prescribed for a TA by his/her superior, the more the students would benefit in terms of feedback.

The teachers had fewer reservations about individual oral evaluation, but they also had little faith in the evaluator obtaining objective impressions from class discussions. They conceptualized the evaluator more as an observer, reserving more of the final grade for summative, if oral, evaluation. Their concept is most clearly characterized by the traditional image of the laboratory teacher evaluating through lab reports. This also enables the student to individually develop experimental skills and strategies:

> .. when you've got a group of a dozen students - it really depends on whom you have. You won't necessarily get into discussion, you won't get everybody contributing equally. You'll get the leaders, and then the others who don't really think about it. I think the nice thing about the independent experiment design is every individual having to think about the project. Group discussion, I mean it's obviously beneficial, but it tends to be led by a few people who either know what they're doing or think they know what they're doing. (faculty interview, p. 7)

According to one teacher, a grade is often arrived at without a concrete scheme. This contrasts with the students' view above:

> I think for the most part as certain persons are concerned, probably as far as you [the evaluator] are concerned, it really does come out of thin air, because it's more a feeling, and there's nothing in terms of obvious criteria that you can write down. So it is sort of a gut reaction to how much you perceive the student integrating. (faculty interview, p. 9)

The TA pointed out that the concept of the evaluator has to remain adaptable to contextual variables such as class size. In a class as small as MB3A06, consisting of relatively mature undergraduate students, the teacher has the opportunity to establish on-on-one contact with each student and therefore does not have to rely on group activities alone for evaluation. Despite these thoughtful comments it appears that the teachers were not fully aware of many of the students' concerns mentioned above.

The milieu representatives favoured summative evaluation even more. Their concept of the evaluator involves some participation through formative oral evaluation, but it emphasizes written summative evaluation. This places the evaluator in a more passive, observing role than did the concepts described by the other two groups.

3.3. The Teacher As Curriculum Planner

All the participants appeared to be aware of the function of the teacher in curriculum planning. Again it should be noted that the concept of "teacher" remains very heterogeneous, especially with respect to rights and duties towards curriculum development. The TA has the least amount of these rights and duties, the lecturer a good deal more, the faculty members even more (at least in the long run). Since curriculum planning in its basic outlines is usually carried out at the departmental level some of these rights and duties lie beyond these faculty members, with authorities who are not closely familiar with the course. Naturally, all of these persons are limited in their freedom of planning by contextual restraints, resource limitations being the most obvious.

Although most of the students were probably only vaguely familiar with these details, their comments revealed few discrepancies compared to the comments from the teachers and the milieu representatives. Occasionally some students seemed to overestimate the freedom of movement left to the curriculum planners. That is, they seemed to underestimate the power of resource limitations. This was inferred from some rather unrealistic suggestions for curriculum modifications. At other times, however, the students seemed quite aware of contextual restraints such as logistics, manpower, and marking time. In general, then, it can be surmised that in this study the concept of the teacher as curriculum planner appeared rather homogeneous across the commonplaces.

4. THE MILIEU COMMONPLACE

4.1. Range of the Milieu Commonplace in This Instance

Much of what constitutes the milieu for a course like MB3A06 is determined by the activities, aspirations, and fates of the students who graduated from the course. In this case most of them would enter the forth year of the MBB programme. A few would attempt to enter medical school. Occasionally one would transfer to another programme, such as honours biology. To date, no student has left the programme by any other route, e.g. by dropping out. The field would diversify much more once the students graduated from the programme. The vast majority of the graduates entered graduate school, many at McMaster. Some would again attempt to enter medical school. A number of other postgraduate programmes provide additional options (at least one graduate went to law school). An additional option, which was rarely if ever chosen, was employment in the biotechnology industry. From this numerical distribution it follows that the most appropriate candidates for mileu representation were prospective graduate student supervisors. Other candidates were faculty members and university administrators.

Milieu constitutes also the part of the learning environment which is not under the teacher's power to change. This includes the location and certain physical conditions and restrictions of the laboratory, but also more removed considerations such as other courses the students are taking at the time or have taken in the past. Other components of the milieu, such as cultural groups, peer associations, or special interest groups were difficult to identify and find representatives for.

4.2. Differences in Conceptualization of the Milieu

The most striking difference was observed between the apparent conceptualizations by the students and teachers and the description given above. Of the six responding students, five have since entered graduate school and one has entered medical school. Despite the fact that graduate school appears to be the predominant goal for graduates, alternative goals do exist. Yet all milieu-related comments from students and teachers refer to graduate school almost exclusively. This is especially obvious with respect to their preferences for instructional objectives, and teaching methods (see also the excerpts from student interview 1, cited in section 1.1.). The following is a typical statement:

> What I wanted to get out of this was a good solid basis in molecular biology, be that techniques, approaches, that sort of thing, which would prepare me for further education - whatever that would be, grad school, med school. I'd always wanted to go into research, so what I was looking for was a preparation for that. (student interview 1, p. 1)

Also, subject matter considerations were voiced only within the context of the MBB programme, occasionally with reference to prerequisites for graduate school. It seems that the participants conceptualized the milieu more narrowly than they might have. The possibility that a student might not finish the programme or had different aspirations than a career in research was simply not taken into account, or at least not vocalized.

A characteristic which seemed particular to the students' concept of the milieu was their reliance on elements of the milieu for arousing student interest in the subject' matter. This view was also expressed by the TA. Whenever a student made a reference to industrial applications in the curriculum it was obviously meant to function as an attention-getter and motivator, much less as a serious reference to career opportunities. It was interesting tidbits of this kind that were allegedly missing in courses which the students considered "boring".

> The stuff that always interested me for example was really elegant or clever applications of genetic engineering to biotechnology. .. things with potentially commercial applications. Things that were sort of outside the norm of the pedantic scientific method that people can instantly relate to. (student interview 1, p.7)

Another peculiarity of the students' concept lay in their sensitivity to the issue of competition among students, which is caused by the milieu. As described in section 1.2.5., the students were hesitant about peer evaluation of general participation and student presentations. They named competition for marks and personal differences and affiliations as problematic circumstances. The teachers, too, were sceptical about peer evaluation, but perhaps for different reasons. The students recognized the role of contextual factors in determining the milieu part of the learning environment (section 1.2.1.).

The teachers's concept of the milieu also showed some particular characteristics. There was the reliance on parts of the milieu to help with the teaching of independent thinking and problem solving (see section 3.1.2.): the opinion that the student has to almost teach him/herself, within an appropriate milieu. Secondly, there was the notion that some effects of the milieu, such as misguided motivation or neglect of descriptive science, are detrimental and have to be counteracted or at least channeled by the teacher (section 1.2.4.). Thirdly, there was a rare allusion to the fact that the course and the MBB programme may be pursuing instructional objectives that could benefit graduates in a wider range of careers:

> What you are doing I think in a course that is technically oriented and looking at the ability of individuals to generate experiments and to evaluate data is [teaching] another skill level that I don't think is all that well tested. I think a lot of people who drop out of high school may be far better at these skills. Even the guys that become automobile mechanics are in fact using the very skills I'm talking about in their work, and they become lots of other things. (faculty interview, p. 1)

The teachers also pointed out that a techniques-oriented course could help with summer placement of undergraduate students. Thus, the curriculum could have an influence on students' lives outside the MBB programme and/or graduate school. Finally, as did the students, the teachers recognized the powerful influence of contextual factors from the milieu, such as university policy, departmental policy, and restrictions of budget, manpower and space.

The representatives of the milieu alone appeared to have a somewhat more comprehensive view of possible avenues of the students' professional development. This is discussed in the follwing section.

4.3. Heterogeneity of the Milieu

In this study, the milieu was represented by four participants. Two were faculty members from departments (chemistry and microbiology) that had no direct connection with the MBB programme. One was a representative of the McMaster Medical School, and the fourth was the chairman of the Department of Biology, in which the MBB students take the majority of their courses.

The comments from the milieu representatives revealed much greater heterogeneity than did the comments from the representatives of the other commonplaces. Heterogeneity was especially obvious in the following instances:

4.3.1. Student conceptualization

Three major sources of heterogeneity were apparent in the ways the students were conceptualized by the representatives of the milieu. First, the priorities in instructional objectives differed considerably. As described in section 1.1, the representative of the medical school preferred a different set of objectives for prospective grad students than the more research-oriented milieu representatives. Two of her top-ranking objectives, critical thinking and integrating information, also received rankings of "utmost" and "major" importance, respectively, by the others. However, she also considered oral communication skills and ability for teamwork of utmost importance. These two objectives were given only minor importance by the others. Conversely, she attributed minor importance to the development of lab skills and library skills, objectives that were given utmost and major importance by the others.

Secondly, the views on the ideal balance between intellectual cooperation among students and independent work were found to differ (section 1.2.1). The medical school representative advocated that 70 % of all written assignments should be carried out cooperatively by the students. The other representatives' recommendations varied from 10 to 30 %.

Thirdly, the milieu's views on the suitability of evaluation instruments and on student involvement in evaluation differed widely (section 1.2.5). The medical school representative favoured to evaluate student participation, generally in class activities and specifically in labtalks. She also recommended peer evaluation for these criteria over evaluation by the instructor. The other representatives favoured formal examinations and presentations and almost unanimously rejected any alternative to evaluation by the instructor.

In all three cases the discrepancy was clearly located between the medical school representative and members of the faculty of science. It reflects the fact that the medical school is using specific criteria in their applicant selection process which differ quite significantly from the criteria used by the science graduate schools. It shows that the reasons for these differences in selection criteria lie in a differential conceptualization of the student commonplace. These differences encompass elements of the entire teaching process, from objectives through methodology to evaluation. In a deliberation, these differences are likely to cause considerable discussion and prolonged struggles for compromises. It is interesting to note that the conceptualization of the students by the medical school representatives has very little in common with the conceptualizations by the students themselves.

4.3.2. Subject matter conceptualization

In view of the differences in the milieu's conceptualizations of the student, it is not surprising that a similar heterogeneity prevails regarding subject matter (section 2.1). Only two of the four representatives considered themselves competent to recommend specific subject areas for the MB3A06 curriculum. One of these was the representative of the medical school. Yet even the two agreed only on two subject areas from a list of twelve, when asked which they considered indispensable for a third year lab course in molecular biology and biotechnology. Three other subject areas from the list were identified by both as "useful but not essential". With regard to experimental technology, there was not a single point of agreement in a list of eleven areas of technology. Concerning working experience with specific biological specimens, they only agreed on bacteria as being indispensable specimens, from a list of seven. In summary, it can be concluded that in a deliberation some milieu representatives are likely to not venture opinions on subject matter considerations because they do not feel competent. Yet even the opinions that are voiced would give ample grounds for extensive debates and discussions. The differences in conceptualization can not be entirely a consequence of the lack of personal experience with this course, because extensive differences in opinions were also apparent on the teachers' side.

Independent of specific topics, the milieu representatives showed heterogeneity in their preference for theory versus practice, as did the teachers (section 2.4). The medical school representative advocated that only 20 % of a student's worktime be spent on theory, perhaps in an effort to adapt MB3A06 more to the McMaster medical school programme which is strongly oriented towards self-directed learning and hands-on experience. Two other milieu representatives advocated 55 % and 60 %, respectively (the fourth representative had no opinion). While the majority of the milieu as represented here opted clearly for a higher content of theory than is presently the case in MB3A06, there would be no clear consensus in a deliberation. It can be concluded that the rift among the teachers between advocates of the project approach and the advocates of a more theoretical approach would probably not be readily bridged by a consensus coming from the milieu.

4.3.3. Teacher Conceptualization

The heterogeneity was less obvious with the milieu representatives' conceptualizations of the teacher commonplace. This impression came mainly from the views on the teacher as demonstrator (section 3.1.1), and from comments on the questionnaires. The one obvious point of contention involved the teacher as evaluator, as was pointed out in connection with the milieu's conceptialization of the students (section 4.3.1).

Although there were differences in individual rankings of evaluation instruments, the ranges of ratings along the top of figure 4 show that the milieu showed no greater heterogeneity than the other commonplaces with regard to their rankings of evaluation instruments. Much more severe differences of opinions concerned the overall prominence of the teacher as evaluator versus the students as evaluators.

To summarize, much of the heterogeneity in the milieu was caused by discrepancies in conceptualization by research-oriented faculty members and by the representative of the medical school. There are several possible explanations for this heterogeneity. One is that it is merely a result of chance fluctuation caused by this particular choice of participants. However, a number of observations suggest otherwise: The division showed consistency between the parties mentioned. The different subject matter conceptualization parallelled the medical curriculum and faculty of science graduate school curricula. Conceptional differences correlated with differences in professional backgrounds of research and medical school. It seems more likely that the heterogeneity was caused by deep differences in implicit instructional objectives, caused in part by the variety of professional backgrounds. Assuming that the heterogeneity is significant it could have serious repercussions on the successful process of a deliberation. On the other hand, heterogeneity has been recognized by educational theorists as a requirement for a successful deliberation. The art of the deliberation chairperson, then, becomes to find the appropriate optimum.

This heterogeneity means that that the course can obviously not conform well with all expectations from the milieu. However, the negative consequences of such a non-conformity are minor, since it is the programme as a whole that prepares students for their further professional development within the milieu.

4.4. Involvement of the Milieu in Curriculum Planning

Despite the fact that students, teachers, and milieu representatives did not address in detail the curriculum development process itself, it was obvious that they did alot a certain role in the process to the milieu. This role was somewhat limited as a result of the limitations in the conceptualizations of the milieu, as described above. Within these limits, however, milieu considerations were accepted by the participants as being very important for the development of an effective curriculum. Thus, requirements made on graduate students by the graduate school curriculum were probably recognized to influence greatly the choice of instructional objectives, implicit or explicit, for courses like MB3A06 and for programmes like the MBB programme. Also, the important role of contextual factors is recognized, as mentioned above. These considerations were obviously shared by teachers (i.e., the faculty in charge of the course) and by milieu representatives such as university administrators and faculty outside the actual course. However, the students, too, recognized the impact of contextual limitations imposed by the milieu. This general acceptance of the milieu as an important source of input in curriculum design may make it easier for the milieu representatives to be accepted as equals into a deliberation.

In summary, these findings allow a number of conclusions about the nature of a hypothetical deliberation on the curriculum of MB 1A06. These conclusions will be considered in more detail in the discussion. With the exception of some of the milieu representatives, the participants would probably find a ready consensus on the major instructional objectives. This would be augmented by a widespread agreement among the teachers and students that the current curriculum does not achieve the most important objectives to a satisfactory extent. The deliberation would then focus on appropriate innovations in the means towards these ends. Differences in the conceptualizations of the commonplaces are likely to surface at this point. The students tended to view themselves as slight underachievers, somewhat shy and deficient in some analytical abilities, who could do much better if only "the course" could be improved. The teachers and some milieu representatives tended to view the students as more severe underachievers who sometimes lack the necessary detachment for making objective decisions (as in evaluation), and they see less potential for improvement in the curriculum. This may prevent the students from being recognized by the others as an equal party in the deliberation. There is also considerable danger that the deliberation may become bogged down over mere subject matter considerations, given the wide variation in priorities among teachers and milieu representatives. Even beyond topical content, the "techniques versus project" controversy among the teachers and the "experience versus inculcation" debate between students and teachers would render the subject matter the main topic of contention. With the considerable heterogeneity among the milieu representatives there is little hope of a general arbitrating influence from that side. Controversy will also arise from differences in the conceptualizations of the teacher commonplace. The students envisioned an actively guiding facilitator of experiential learning who emphasizes formative over summative evaluation. Teachers and milieu representatives, while far from united, generally favoured a more passive facilitator role, with a greater emphasis on summative and oral evaluation. Differences in the conceptualizations of the milieu, although real, are less likely to contribute to controversy unless some milieu representatives pursue their agenda with considerable rigour.

FINDINGS II:

SUGGESTIONS FOR THE MB306 CURRICULUM

In this chapter, the consensus and suggestions for curriculum revision that emerged from the data are summarized, and their benefits and feasibility is discussed. The majority of the suggestions fall into four major categories of innovations, concerning learning objectives, content, teaching methods, and student evaluation. These four categories are summarized below. The most frequently suggested major innovations were revision of the manual, weekly lab meetings, specification of objectives, and formulation of topics for student experts. This chapter is intended primarily for the perusal by future instructors in MB3A06.

1. Learning Objectives

As was determined in the previous chapter, there was considerable agreement among the respondents on what the most important learning objectives for MB3A06 should be. In contrast, calls for improvement varied considerable. Considerable potential for improvement was considered to lie with teaching experimental design, oral presentation skills, and integration for information. The students also called for greater efforts to teach problem solving skills. The specific suggestions outlined below were put forth to contribute towards these objectives.

The teaching of laboratory skills, although considered of secondary importance, could be improved quite easily in the opinions of most respondents. It was suggested that the instructor emphasize the importance of keeping an accurate logbook of experimental work throughout the course. This activity was considered more important than the writing of lab reports. The TA should inspect the logbooks periodically.

2. Content

The students made several suggestions for subject material to be incorporated into the curriculum. One which is logistically feasible aims at using a "biotechnologically important gene" in the GAL induction experiment in yeast, instead of lac z. Several repondents noted that using biotechnologically important model systems and examples from the student's daily life was likely to bolster the students' motivation (section 3.1.).

A faculty member suggested to teach a basic in vitro procedure for determining enzyme activity quantitatively. The students claim that such a procedure is currently not included anywhere in the MBB programme. One of the two enzymatic activities which are currently used in MB3A06 for qualitative in vivo screening, gus or Lac z, could be employed for a qualitative in vitro assay. The Lac z assay would be the cheaper one to implement.

It was also suggested that the manual be reorganized to include more theory. This would serve to emphasize the importance of the students' experiments within the context of important concepts and significant discoveries in the field. It could be accomplished by the carefully dosed incorporation of research literature and background information. The instructor should take great care in selecting the research literature, using examples in which "the techniques or the methods of drawing the results were as important as the topic on which the results were obtained." (faculty interview, p. 7)

3. Teaching Methods

Bugelski (1971) suggested that a selection of teaching methods should take into account the various steps in the learning process. His list of steps include motivation, attention, discrimination, encoding, response, and feedback. The suggestions regarding teaching methods that emerged from this study are organized below according to these steps.

3.1. Motivation and Attention

Motivation was not viewed as a problematic issue by the respondents. Nevertheless some of the suggestions, if implemented, would likely serve to increase motivation through more frequent positive reinforcement. The importance of positive reinforcement in the strengthening of motivation is widely recognized (e.g. by Pascal and Geis, 1970).

- The inclusion of more theory into the lab manual, as suggested in the previous section, might serve to increase motivation in laboratory experiments by illustrating their significance in the context of the subject matter.

- The scheduling of regular lab meetings to discuss experimental design, results, procedures, and research literature might increase motivation. Frequent discussions in small groups provide an excellent means for positive feedback (Beilin and Rabow, 1979).
  In order to provide additional motivation, marks should be given for attendance at the lab meetings.

- Independent laboratory work, particularly during the section on bacterial metabolic mutants, was recognized as enhancing motivation by facilitating personal success experiences and eliminating certain misconceptions about the field. It also stimulated discussion. It was suggested to expand this learning mode into other sections of the course and to assign more work individually instead of in pairs.

Severe limitations in resources render this suggestion less feasible than most others.

- Students suggested that the instructor examine more carefully how the students perceive his/her attitude towards them, e.g. through instructor evaluations of past years. A subsequent modification in instructor behaviour might in turn improve the students' attitudes.

3.2. Discrimination

Discrimination by students of relevant information against background information can be made easier by more effectively communicating the course objectives. Since inadequate communication of learning objectives to the students is often a major factor in limiting student achievement (Stice, 1976), ways to improve communication should be pursued. The following suggestions were made:

- The instructor should choose objectives emphasized in this survey and formulate them more concretely for communication to the students. A method for this has been described by Geis (1972).

- The objectives should be included explicitly in the manual and in the discussions.

3.3. Encoding

The subject material should be presented in a form that facilitates easy encoding by the student. The following suggestions were made:

- The instructor should use examples, analogies, adequate information density, and "bite-sized" information packages. This pertains to the writing of the lab manual as well as to lecture periods during the lab meetings.

- The different learner types could be accommodated by providing alternative forms of presentation of the material (e.g. reading and lecturing) and alternative ways of formative student evaluation (e.g. extra experiments, oral presentations, student experts).

- The lab manual should include a more explicit prescriptive section on how to write lab reports. The section should use research publications as models for the format, as well as referals to the guidelines by Day (1988). It should also contain an explicit marking scheme.

3.4. Response and Feedback

Learning is best facilitated if the student has a chance to respond to what is learned. Frequent recall along with positive reinforcement during discussions can accomplish that. The key lies in giving the students ample opportunity and sufficient obligation to participate in such activities. Learning also becomes more effective if feedback from the instructor is quick. The following suggestions were made:

- Peer Teaching: The instructor should assign or encourage the creation of student experts on specific narrow topics, e.g. transposon mutagenesis. These students should become knowledgeable enough to present the topic to their peers, to answer questions from their peers, and to chair class discussions. Advice on how to implement this concept could be obtained from the instructors at the McMaster Medical School and from the literature (e.g., Ferrier, Marrin, and Seidmann, 1987). Care should be taken to equalize the students' individual workloads.

- The revision of the lab manual, mentioned in section 3.1., should also seek to transform the cut-and-dried protocols into a strategy outline. The translation of this outline into actual experiments should then be done jointly, through discussion. This might help students appreciate the practical value of experimental techniques.

- Student responses and feedback should be accommodated by the weekly lab meetings, through the following activities:
  Discussions of experimental procedures;
  Discussions chaired by student experts;
  Oral student presentations of experiments and results;
  Joint analysis and discussion of key research papers;
  Suggestions how to prepare the lab reports;

- The instructor is responsible for an effective chairing of the class discussions. This includes ensuring that the class discussions do not become unduly dominated by a minority of students, so that every student receives a share of response time and adequate feedback. It also includes a strict control over the subject of the discussion, to prevent losing students over subjects too esoteric.

- The format for student presentations should be individual, or in pairs if the students are compatible. They should not be evaluated by the students. They should be short, perhaps only five minutes overviews over what they did and what results they obtained.

- The timing of the learning activities should be shifted in the following way: More demonstrations should be done by the instructor initially, then individual work should be phased in later during the term. This would provide more data during the first weeks of the course and make it possible to shift the lab reports to earlier dates. At the same time, more reading could be assigned during those first weeks. This would help to compensate for the undue accumulation of workloads toward the end of the term, caused mainly by other courses, and give the student more time to respond. Also, feedback would be improved by assigning a larger number of lab reports and evaluating them more quickly.

- Individualizing the laboratory work, mentioned in section 3.1., would also serve to broaden the basis for class discussion by providing a wider spectrum of results.

4. Student Evaluation

Two general trends can be seen in the suggestions made on evaluation: a trend from summative evaluation towards formative evaluation, and a trend from written evaluation towards oral evaluation. It was suggested to decrease the weighting of the written final exam from 40 % to 30 %, or to eliminate it altogether, in favour of oral evaluation of student presentations and the performance of student experts. The pressure on the students in oral presentations could be alleviated by doing the presentations in pairs, provided they are compatible. Elimination of the final exam would also contribute towards a shift of the workload towards earlier in the term, which would be highly desirable, as mentioned above.

If the final exam is retained it should be made more valid, i.e. it should cover the background reading, the material in the manual, and the material covered in the lab meetings, to the relative extents that these contributed to the instructional objectives. The suggestions on the methods of formative evaluations were discussed in section 3.4. above.

5. Evaluation of the Recommended Changes

How much of an improvement would the recommended changes actually constitute? By using Fensham's (1977) dimensions for evaluation of university curricula a detailed comparison is possible a priori between the old curriculum and the recommended new curriculum. Fensham classifies his criteria into antecedents, transactions, and outcomes.

One of the anticedents, the amount of institutional response to differences in entry-level knowledge and skills would increase. The main reason would be the increased feedback that students would receive through the frequent discussions.

Two of the transactions, the extent to which different learning types and learning speeds are accomodated by alternative teaching methods, would increase. This would be a result of the increase in self-directed learning, connected with independent assignments, as well as of the implementation of oral presentations and student expert-mediated discussions as alternative teaching methods.

Two of the outcomes, the extent to which students can determine the subject content, and the extent to which continuous (=formative) evaluation is used, would also increase. The reason would be the greater emphasis on independent work and the decreased emphasis on the final exam, respectively.

From this comparison one can conclude that the recommended changes would constitute a significant improvement, at least through the lens of Fensham's (1977) criteria. Naturally, the actual evaluation of the changes requires their implementation. That evaluation, which would include the evaluation of teaching methods and the assessment of the extent that learning objectives have been achieved, would be left to the course instructor. The book by Gibbs, Habeshaw, and Habeshaw (1988) might serve as a useful guide towards this end.

The recommended innovations do not exceed the time and effort normally spent by the average instructor in preparing for a course. There are also no major costs involved in these innovations. From the point of resources therefore, no significant impediment seems apparent.

As Beard (1974) has pointed out, changes in the curriculum must be accompanied by appropriate changes in departmental organization to ensure maximum effectiveness. Therefore the proposed changes in the curriculum for MB 3A06 have to be viewed through the lens of departmental policy and be examined for their feasibility. This has to be included into the task of the instructor who implements the curriculum.

DISCUSSION

This discussion is aimed at the following: The conceptualizations of the commonplaces by the different participants are compared, and conclusions are drawn as to what shape a hypothetical deliberation between the participants might assume. Possible outcomes and potential problems for this deliberation and some solutions are identified. Also, observations and conclusions from the study are used to formulate some general conclusions about the potential of the practical in curriculum development at universities.

Differences in Conceptualizations of the Commonplaces

If an actual deliberation took place among the participants in this study, many of the views that became apparent from these data would be voiced and juxtaposed. Thus, the findings from this study can be used to describe the situation at the onset of the deliberation, on which the process of platform formation would be based. Also, we can speculate that the most prominent conceptual differences identified in the findings might give rise to some of the most contentious issues in the actual deliberation. It is therefore of interest to identify and characterize such differences from the findings. However, not all of the differences identified in the findings may bear such significance. Sometimes dissent may be only apparent as a result of insufficient data. A deliberation might quickly and fairly resolve the subject by eliminating a misunderstanding or by means of a simple compromise. The probablility of such an event also depends on how strongly a certain view is held, a measure which the findings often do not allow an estimation for. On the other hand, some significant differences may not have been unearthed by the methods employed. Such unforeseen differences could shape the deliberation in unpredicatable ways. Bearing in mind these cautionary remarks, the following conceptual differences can be considered likely to play a role in shaping a deliberation:

The Student Commonplace

Most of the participants visualized a good student to be capable of independent thinking. They recognized this ability as a prerequisite for good performance in laboratory work, independent projects, and in the application of theory. The representatives of the milieu expressed somewhat different preferences than the others.

A discrepancy was noted between the objectives most favoured by the faculty and the objectives actually pursued by them in their teaching methods. The former focused on independent thinking, the latter on content. This finding parallels the finding of Stark and coworkers (1989) that generally curriculum planning at universities does not pursue the stated objectives. Even voices from inside Ontario universities seem to acknowledge this discrepancy (Gibbins, 1988). This inherent contradiction, once illuminated in a deliberation, may give rise to some animosity and frustration. On the other hand, it may provide an educative opportunity for some of the participants.

A possible source of contention on objectives was noticeable in the responses of the milieu representatives. The distribution in MB3A06 of intellectual work, consisting of 70 % independent and 30 % cooperative work, conforms with the ideal values suggested by the two milieu representatives from the natural sciences (90/10 and 70/30) but not with the medical school representative (30/70). The conclusion is that MB3A06 does probably not prepare students well for the McMaster medical programme. However, for the curriculum planner for MB3A06 this does not constitute an immediate problem. Despite the fact that a significant fraction of the Molecular Biology students apply for medical school, preparation for that career is not one of the objectives of the Molecular Biology and Biotechnology programme at this time. The question whether it should be may exceed the scope of a deliberation on this course.

The students saw themselves as underachievers who would benefit considerably from modifications to the curriculum. The teachers valued the students' achievement higher than the students valued their own achievement, but they also considered the curriculum less "improvable". Generally, the teachers appeared to be less innovative, less inclined to experiment, and more inclined to live with the status quo, perhaps because they had been obliged to do just that in many instances throughout their careers. Assuming that the major difference between students and teachers in the conceptualization of objectives concerns what is achievable, the deliberation is likely to concern itself much more with the means towards certain objectives than with the objectives themselves. A similar observation was made by Hannay and Seller (1987), which led them to propose teaching methodology as a possible fifth commonplace. The following issue serves as an example. Again it should be cautioned, though, that the findings may not have unearthed certain deepergoing differences on instructional objectives.

Both students and teachers expressed a preference for individualized learning activities. The teachers, particularly the TA, expressed considerable confidence in the students' abilities to manage their own time and resources effectively. They regarded the need to teach a certain number of skills as the major obstacle to further individualizing instruction in MB3A06. The students themselves, however, were less confident. They perceived individualization to be strongly limited by logistical problems, limited resources, and lack of student motivation. The milieu was divided in their priorities for individualized instruction. Overall, the issue of individualizing instruction in MB3A06 resembles more a procedural practical problem (Reid, 1979) than an uncertain one. It is therefore less likely to draw much contention in a deliberation.

Other observations also indicate that a considerable portion of the deliberation would probably focus on teaching methodology. For example, differing views became apparent on the role of class discussions, on how to implement oral presentations and discussions while preventing them from being dominated, and on how to limit the scope and subject of discussions to maximize their benefit to all students. Some of these problems might again turn out to be procedural, but care would have to be taken not to "steamroll" any minority views. The milieu representatives, who were not consulted on this in depth, might have different visions on how these activities should be conducted. Consultation of additional milieu representatives, to include a wider spectrum of teaching experiences, might be of help.

The role of research literature qualifies as another contended means of instruction. The teachers seemed more inclined to assign individual papers for presentation, while the students showed little enthusiasm for that. They claimed that third year students lacked sufficient analytical skills. This indicates a deeper difference in the conceptualiztions of the student which a deliberation would have to concern itself with.

The apparent general agreement on broad instructional objectives also extended into a general disregard for affective objectives. The milieu representatives, who did not contribute to this picture, might express different opinions in a deliberation.

In contrast, a very obvious point of contention was the degree of student involvement in evaluation. Despite some reports of useful and fair systems of peer evaluation (Whit, 1980) and self-evaluation (Boud and Lublin, 1983, Boud, 1979), even from McMaster University (Woodward, 1981), the traditional instructor-mediated methods of evaluation at universities have largely remained in place. The students welcomed the idea of peer evaluation, while the teachers showed scepticism. The milieu representatives were so divided over the subject that a deliberation may unearth profound conceptual differences in the roles of evaluation in general. At this point in the deliberation the chairperson might have to become more actively involved to ensure that the deliberation remains productive.

The Subject Matter Commonplace

As noted earlier, sole representatives for the subject matter could not be identified in this study. The resulting underrepresentation would likely cause complications in a deliberation. A deliberation would almost certainly suffer from a lack of arbitration in cases of subject matter disputes between the other representatives, particularly the teachers. As pointed out in the findings section, there was no shortage of differences in points of view on subject matter. It would be up to the chairperson to attempt to compensate for this underrepresentation. Such a role would require comprehensive knowledge and experience in the theory and practice of molecular biology, as well as a position of sufficient academic authority in the field.

Disputes over subject matter considerations are most likely to arise from the teachers. The findings show that the students felt rather ambivalent about subject matter. The findings also indicate that the milieu representatives, while holding very divergent views, often felt not familiar enough with the course to voice a valid opinion on subject matter or to defend a certain opinion very strongly. A likely outcome of a deliberation is that the contributions by the milieu representatives would carry less weight, because this lack of familiarity would be interpreted by the other participants as a lack of competence. As in any deliberation about a specific course, it would be up to the chairperson or the faciltator to attempt to achieve a balance bwetween the camps of the "insiders" and the "outsiders". Achieving a balance in the numbers of representatives might help a priori.

As noted in the findings (section 2.2), compromises between opposing conceptualizations of the subject matter may sometimes be difficult to find. One strong point of contention of this kind would be between advocates of a "techniques course" and advocates of a "project course". The majority of the students would likely support the latter point of view, while the teachers would be deeply divided. Perhaps the weight of the numbers would tilt the outcome to the project side, but, as Schwab (1983) and others pointed out repeatedly, a successful deliberation would have to transcend this confrontational situation, perhaps by exploring and discussing the underlying value systems. Other major points of contention include the following:

Transmission versus transaction: Students tended toward the latter orientation while the majority of the teachers subscibed to the former. The milieu was divided.

Comprehensiveness versus specialization: This dispute would probably follow along the lines of the "techniques versus project" dispute mentioned above.

Theory versus practice: Only the milieu representatives called for the inclusion of more theory. With the majority of the participants agreeing with the current balance, the point of dispute would probably shift towards the selection of specific bits of theory, which the teachers were greatly divided over. It would be up to the other participants to help obtain a consensus.

The Teacher Commonplace

Differences in the conceptualizations of the teacher commonplace will surface in the deliberation as soon as it moves from the subject of "what to teach" to "how to teach it". The use of demonstrations by the teacher in MB3A06 was more frequent than advocated as desirable by the milieu representatives. However, the other participants found the prominent role of demonstrations quite appropriate for this course. As pointed out above, the milieu alone would probably not carry enough weight to sway the views of the others.

Students and teachers were somewhat divided over how prominent a role the teacher should assume during classroom activities. The teachers advocated a relatively low profile, combined with carefully dosed and directed support efforts, while the students advocated a more active role of the teacher. The positions were similar on the specific subject of class discussions, where the students advocated a more stringent chairing function by the teacher than did the teachers themselves. Overall, the differences on this point were probably minor and might be quickly resolved in a deliberation.

Agreement on the teacher's role in revising the lab manual may be reduced to a procedural problem. It seems likely that the students would have little trouble in convincing the other participants of the lab manual's importance. Even their suggestions on the content of the manual might be quickly adopted since they include additions, not deletions. As well, the importance of preparatory duties of teacher and students would probably not be contended once their logistic importance was made clear to all participants. Finally, the teacher's role as curriculum planner was also conceptualized in similar ways by all participants.

In contrast, the teacher's role as evaluator would likely constitute a major point of contention. As mentioned above, the students consistently called for a greater role in their evaluation, while the teachers seemed rather sceptical towards this idea. The milieu was divided. Another division was noticed between the milieu and the others on the balance between formative and summative evaluation. Thirdly, students and teachers were divided over how explicitly instructional objectives should and could be communicated to the students prior to evaluation. It is difficult to speculate on the direction or the outcome of a deliberation on this issue. One advantage of this scenario of general dissent is that the emergence of intransigent factions seems less likely in a deliberation where everybody disagrees with everybody else.

The Milieu Commonplace

The relatively narrow conceptualization of the milieu by students contrasts with the more flexible conceptualization by the teachers, and even more with the milieu representatives' views. Perhaps it is natural for students to define the milieu only through the lens of their own personal experiences and aspirations. Nevertheless, in view of the diverse career paths taken by graduates the possibility of a wider conceptualization of the milieu should at least be brought to the participants' attention. If such a suggestion is not made by any of the participants it would be the responsibility of the chairperson to do so. For instance, in connection with learning objectives, the participants could be introduced to Fuller's (1980) list of learning objectives in lab instruction that were favoured by industry representatives. Among them are familiarization with real-world examples and phenomena, teaching how to design experiments, how to validate assumptions, how to work in groups, management skills, how to apply theory to practical problems, how to learn independently, and knowledge of auxiliary technology. Most of these objectives overlap at least to some extent with the ones discussed in this study. The conceptual differences about the milieu among the participants may turn out less deep than they seem from the available data; perhaps the mere description of certain career decisions taken by actual graduates may convince the participants that a wider scope is justified. Also, the active participation of the milieu representatives may help toward this end.

The heterogeneity among the milieu representatives could have positive and negative effects on the deliberation. It would serve to stimulate the deliberation by introducing a wider spectrum of viewpoints and approaches, thus increasing the scope of the alternatives generated. Different milieu representatives would at different times side with different factions in the deliberation which would serve to prevent any enduring polarization. On the other hand, certain minority views held by individual milieu representatives might be labelled by the other participants as unrealistic or inapplicable and might thus not receive the attention they deserve. The opinions of these representatives might subsequently be considered less relevant than those of the others and be unduly neglected.

Applicability of Deliberation to Curriculum Development at Universities

The conceptual differences outlined above allow a certain amount of speculation on the nature of a deliberation and its outcome. Such speculations become more tentative the more they attempt to generalize. On the other hand, the findings agree in some respects with the planning practices reported by Stark and coworkers (1989) for introductory courses at a large variety of colleges and universities. Agreement is found in the primary instructional objective (independent thinking), in the basic criterion for selecting content, and in the roles of contextual influences. In most other respects the two studies are not comparable because of the disparate nature of the courses they are focused on.

The participants in this study revealed considerable reflection on course objectives, which creates a situation much more conducive to deliberation than the one described by Elton (1983). Also, the discrepancy between course objectives and evaluated student performance was not noticed to be as drastic as described by Beard and Pole (1971) and others. It seems that, contrary to some disheartening reports, certain possibilities do exist for the implementation of a deliberative approach to curriculum planning, at least in this case. Yet during the course of this study it turned out that an actual deliberation could not be implemented without a massive investment of time, resources, and cooperation by administrators.

Another potential obstacle toward a deliberation lies in certain discrepancies in positions of power between students and faculty (Hannay, 1989). The participants were obviously aware of such discrepancies. There is even the possibility of resistance to the participation of students in the deliberation; the findings (section 1.3.) suggest considerable scepticism on the part of the teachers toward student participation in curriculum planning. The chair would have to endeavour that contributions from the students are noted and respected by the others. Some milieu representatives, such as the medical school representative in this study, may also find themselves only hesitatingly accepted as equals by the teachers. In this case the reason would be less a discrepancy in positions of power but a discrepancy in views on competence and instructional objectives.

Thirdly, some participants, particularly in the first round, did not appear motivated enough to actively participate in a live meeting. This was gathered from the fact that only 6/13 of the questionnaires were returned by the students, and from some of the responses in the questionnaires.

Potential Benefits of the Approach Taken in this Study

In the case that the above obstacles toward deliberation turn out prohibitive, the curriculum planner(s) could resort to the prescriptive model by Malone (1991). Malone's approach has much in common with the approach taken in this project, but she does not explicitly recognize the importance of deliberation. As was done in this project, contributions from a number of participants could still be solicited through questionnaires and interviews, but their amalgamation into curriculum could be performed by a smaller team than envisioned by Schwab. This would alleviate some of the organizational problems and other obstacles, but would probably devalue the deliberation. It would result in a deliberation by proxy. Yet, in her call for action on the practical, Hannay (1989) suggested for researchers to investigate alternative ways of representing the commonplaces. This approach may lead to such an alternative way. It also may have the advantage of putting some participants more at ease. Some people who do not communicate well in groups feel more comfortable on a one-to-one basis. If an important point has been omitted in a questionnaire or interview the error can easily be corrected at a later time. Interpersonal problems such as those resulting from unequal personal power could also be circumvented. In the remainder of this section, the potential outcomes of such an approach, as judged from this project, are compared to those of a full-fledged deliberation.

This project was initiated more out of academic interest than out of "a growing feeling of inadequacy" of existing curriculum, the inititiating circumstance for deliberation as postulated by Schwab (1969a). Walker (1971) suggested a need for justification of existing curriculum decisions as the main initiating circumstance. The initiation of this project followed more along the lines suggested by Walker than Schwab's concept. But the mere concern of "Can we come up with something better by using these new principles?" is not fully covered by either concept. Perhaps the juxtaposition of academic curiosity with the other two initiating circumstances would serve to stimulate the fancy of more university faculty and lead to more frequent attempts at deliberation in postsecondary curriculum planning.

The planning of this project was carried out with an appreciation for the concepts of the practical. The project followed Schwab's (1973) three phases of problem identification, discovery of solutions, and (projected) implementation. The selection of participants had to facilitate equal representation of the four commonplaces. It was considered important that each commonplace did not only receive sufficient consideration but was actually represented by a person. For instance, the McMaster Medical School as an important milieu component was represented by an adminstrator in charge of admissions, instead of a stack of printed requirements, guidelines, and references outlining the School's criteria for acceptance. This approach is not only easier for the curriculum developer but it is considered vital in Schwab's (1971) vision of polyfocal conspectus. At the same time this approach causes much logistical difficulty to the curriculum planner. The fact that the representation of the commonplaces did not follow clearly and exclusively Schwab's four categories may not be an obstacle to deliberation. In fact, the concept of "particularplaces" (Pereira, 1984) postulates an adaptation of the commonplaces to the concrete situation.

The interviews were conducted in a way that would preserve the premises of live deliberation as best as possible under the circumstances. The interviewer often repeated arguments made by previous respondents to elicit further comments, often using identical wordings and phrases. Thus he functioned as a bridge between participants who never met. This constitutes a considerable improvement over the questionnaire method in which such bridging is only possible from one round to the next.

Nevertheless the approach taken in this study can not substitute for a deliberation. It does not stimulate and motivate as much, nor does it facilitate a spiral process. The reason lies in the much reduced communication between the deliberators (Schwab, 1973). A greater amount of experience on the part of the interviewer may have been able to partially compensate for that. The interviewer often attempted to stimulate a discussion by participating beyond the asking of largely premeditated questions, assuming the role of advocatus diaboli or that of the representative of a different commonplace. One objective was to counteract some of the impeding habits identified by Roby (1985) such as "rush to the solution", "shortchanging commonplaces", or "global mentality". Another objective was to ensure that the problems were defined in uncertain terms. The interviewer found that with the number of interviews he became more adept at this activity.

A disadvantage of the questionnaire method is the elimination of personal bias by averaging numerical scores. While numerical scoring is useful for easy acquisition of large amounts of data this feature renders the result less colourful. However, the questionnaire method is an indispensible complement of the interview method because it provides a preliminary platform on which the interviews can take place.

There are indications that some of the participants also benefitted from this project. The four persons who participated in both rounds of data gathering, especially the students and the TA, may have experienced an increased awareness of the concerns and considerations that permeate curriculum planning. Some students were visibly relieved and pleased to find a sanctioned outlet for some of their criticisms and an address for their suggestions. The faculty member who participated in both rounds may have become more aware of some of the students' concerns and sentiments as they were transmitted by the interviewer. It can be concluded that this approach, while probably not as educational as a deliberation had some educational effects on its participants.

Besides its educational effect, the emergence of self- criticism has been named as an indication for a successful deliberation (Roby, 1985). The presence of self criticism in the participants is difficult to determine from the available data. In his interview, one student frequently criticized his conduct at school, but this was most likely part of his personality.

The joint interview with two students developed into a discussion which exhibited some of the characteristics of actual deliberation observed in empirical studies (Hannay and Seller, 1987; Atkins, 1986). For instance, the students' attitudes toward the idea of independent laboratory work changed noticeably after they became aware of the potentials of alternative ways of teaching and learning background material. Such a change in attitude and perception is also a result of the spiral process of deliberation. A constant interweaving of the commonplaces was noticeable, as postulated by Atkins (1986), often digressing from the interviewer's "game plan". Quite frequently however, and largely because of the lack of personal experience on the part of the interviewer, the interview relapsed from discussion into a question-answer-answer format. This meeting would have been even more fruitful had the two students started with less similar platforms. In retrospect it can be concluded that the interviews would have been more effective had they all been conducted with pairs of participants.

In her call for action and further research on the practical, Hannay (1989) posed the question whether consensus was essential for decision making in the practical. This study suggests that the answer may be affirmative. The disagreement about aims of MB3A06 - techniques or independent projects - was never resolved. This disagreement gave rise to a number of disagreements on teaching strategies. In the final evaluation the majority opinion (independent work) dominated over the minority because a compromise did not appear feasible. If an actual deliberation took place, the lack of consensus on this issue may prevent decision making. Schwab (1973) stated that the deliberation does not even conclude when there is agreement. Rather, a preliminary implementation and evaluation should create the feedback for a renewed deliberation. This project identified agreement on some issues and disagreement on others, but in principle this approach, if extended, also allows repeated rounds of implementation and re-evaluation.

From this comparison the following can be concluded: The approach taken in this study, which could be combined with some of Malone's (1991) suggestions, has a number of disadvantages over an actual deliberation. However its relative ease of implementation, combined with the suggested benefits, render this approach at least a viable alternative.

Conclusions About the Future Practice of Curriculum Development at Universities

Returning to the questions put at the end of the introduction, the following conclusions can be drawn with regard to the potential for improvement in the practice of curriculum development:

1. The practical can serve as a useful conceptual framework for the individual university instructor in developing a course curriculum. Even the mere attempt of an implementation of a deliberation induces in the instructor much reflection on teaching, causes him/her to do some reading on education, and requires him/her to communicate with others about ideas on curriculum. All these effects are in themselves beneficial to the state of teaching at the university.

2. In order to sucessfully use the practical the instructor must implement deliberation. A number of variant approaches to this have been described. Schwab's classical approach may be prohibited by contextual limitations. Short and Tomlinson's (1979) effort, although more pluralistic than the average (Stark and coworkers, 1989), lacks representation of some commonplaces and problemation in uncertain terms. Bonser and Grundy's (1989) approach lacks representation of some commonplaces but exhibits spiral structure and educative qualities. Yet it would again probably turn out unfeasible for the average instructor because of the prohibitive requirements for resources. Siegel's (1975) simulated

deliberation appears feasible but excludes living particularplaces. The approach towards the gathering of data as it was taken in this project represents a compromise between the highly effective but probably unfeasible deliberation suggested by Schwab and the "Lone Ranger" type of approach suggested by Malone (1991). Some of its logistic advantages were mentioned in the previous section. Its greatest advantage over existing practices is the equal representation of the commonplaces. Designing a curriculum for business students without consulting business as it was described by Trinkaus and Booke (1980) seems ludicrous but is probably no exaggeration of existing practices. On the other hand, the approach does include a deliberation as fourth phase, if only by proxy.

Independent of their specific problemations, instructors who attempt a deliberative approach would likely concentrate on the deliberation of learning objectives, as was done in this study. Using the recommended objectives as directives, a list of more precise objectives can be compiled that fall under the headings of the recommended ones. A procedure for this has been outlined by Geis (1972). It uses the following sources of objectives:

Course exercises, examinations, assignments

Course outline, outlines of related courses

Taxonomy of learning objectives (Bloom, 1956; Beard, 1969;
McGuire, 1963; Mager, 1975)

Exercises in relevant textbooks

Literature available at resource centres
(e.g. McMaster Instructional Development Centre)

Subject material covered by the course

Although Geis's (1972) procedure was designed for the behaviourist approach in curriculum design it could be beneficial to the practical approach as well. If, as was done in this case, certain broad objectives can be determined by researching the prevailing views among the commonplaces, the instructor can use the procedure to derive more specific objectives for communication to the students, and perhaps for further deliberation. Thus Cox's and Kontiainen's (1973) reasons for the necessity of spelling out educational objectives remain valid. The difference in this case is that this concretization takes place after a consultation of representatives of all four commonplaces.

3. In the light of restrictive budget situations in most university departments the approach taken in this project might represent the maximum effort permitted to be spent on the curriculum of a single course. This would change if the initiative originated from e.g. the department chair, so that individual efforts could be coordinated and combined. In that case the format could be more easily modified towards a more deliberative form, perhaps by organizing several "mini-deliberations" of the kind that took place almost accidentally in the student interview in this project.

4. One additional advantage that is tempting to speculate on is the proliferative potential of this method. A method that works tends to be employed again the next time. If the method and its success becomes communicated to others then its use will proliferate among them. The advantage of the approach taken in this project lies in the fact that it already includes communication. If it worked, others will know because they participated in it. Those participating faculty members will be likely to at worst reflect more on their own curriculum and at best make an attempt of their own. Thus it may be hoped that this approach, although not exactly true to Schwab's practical in many aspects, represents a

useful step towards implementation of the practical - and a step which is relatively easy to take for most university instructors.

APPENDIX

Name (optional): ....

Year when I took MB 3A06: ....

QUESTIONAIRE TYPE 1

1. LEARNING OBJECTIVES

The following is a list of learning objectives which most people consider desirable. Instructions on what to do with it follow on the next page.

	i	ii	iii
1. practical abilities and skills in lab techniques			
2. knowledge of theory behind lab techniques, and ability to apply that knowledge to the laboratory situation			
3. ability to independently design simple experiments			
4. ability to write good lab reports			
5. ability to work independently, in the laboratory and in the library			
6. ability to work in a team			
7. ability to integrate information learnt at different times and different places			
8. ability to think a problem through			
9. knowledge of the subject matter taught in this programme at this level			
10. oral presentation skills			
11. oral communication skills			
12. library skills			
13. ability to evaluate the proposals, performances, and ideas of peers in their written and oral reports			
Additional objectives which you consider important:(please specify)			

Rate the above learning objectives according to the following criteria. Please read the criteria carfully.

i) the degree to which they they ought to be pursued (and possibly be achieved) by the Molecular Biology and Biotechnology programme in general;
Enter the appropriate number into the left column.
(1 = no importance, 2 = minor importance, 3 = average importance, 4 = major importance, 5 = utmost importance)

ii) Now rate them according to the degree to which they they are achieved by this course, Molecular Biology 3A06.
Enter the appropriate number into the middle column.
(5 = I learned 100 % of what I wanted to learn,
4 = 80 %, 3 = 60 %, 2 = 40 %, 1 = less than 20 %)

iii) Now rate the extent to which you think the course should and could be improved to achieve each specific learning objective.
Enter the appropriate number into the right column.
(5 = no improvement possible, 4 = a little improvement possible, 3 = could be improved considerably, 2 = massive potential for improvement, 1 = any change would probably be for the better)

iv) Into the space below write specific ways in which you think that such improvements could be achieved. Use the back page if necessary.

2. SUBJECT MATERIAL

In the last two years the course emphasized, as you know, microbial Genetics and related techniques. Before that, the course emphasized general molecular experiments like Northern blotting, in vitro translation, and protein electrophoresis.
Without having experienced the former version of the course, do you consider this change in course curriculum a positive one?
Please explain the reasons for your answer.

Is there any other subject material which you consider underrepresented in the program (from your present view) and which should be incorporated into this course?

3. PROCESS

In every lab course there has to be a balance between the amounts of experimental work done as demonstration experiments by the instructor, jointly by the class, and independently by each student or labgroup.
In your opinion, was this balance in MB 3A06 appropriate, or did it it lean too much to one side?

There also has to be a balance between intellectual cooperation among students and independent work, epecially when it comes to writing lab reports.
In your opinion, was this balance in MB 3A06 appropriate, or did it it lean too much to one side?

Finally, in every programme and every course there is the dualism of theory (lectures, reading) and practise (labwork, writing).
Would you consider the Molec. Biol. Biotech. programme in general to be well balanced between theory and practise? Explain.

Would you consider this course (MB 3A06) well balanced between theory and practise?

If not, what changes would you recommend?

4. STUDENT EVALUATION

The following assignments can be used toward student evaluation: Rate each assignment in the extent to which you consider it appropriate for MB 3A06. Rate as many assignments as high or as low as you like.
(1 = not at all appropriate, 2 = not very applicable, 3 = somewhat useful, 4 = quite useful, 5 = very much appropriate)

1. written examination	
2. term paper	
3. oral examination	
4. lab reports	
5. oral presentations	
6. participation and contribution in labtalks	
7. subjective evaluation of " general participation"	

The following methods can be used in evaluating student performance:

(a) self-evaluation

(b) evaluation by peers

(c) evaluation by the instructor or TA

For the types of assignments that you rated (4) and (5) in the table above, state which evaluation method you consider most appropriate (a, b, or c).

In your opinion, who else (a group or an individual) should be contacted for additional input in this survey?

ADDITIONAL COMMENTS:

Thank you again for your time and effort !

name: ....

Year when you demonstrated MB3A06: ....

QUESTIONAIRE TYPE 2 (TAs)

1. LEARNING OBJECTIVES

The following is a list of learning objectives which most people consider desirable. Instructions on what to do with it follow on the next page.

	i	ii	iii
1. practical abilities and skills in lab techniques			
2. knowledge of theory behind lab techniques, and ability to apply that knowledge to the laboratory situation			
3. ability to independently design simple experiments			
4. ability to write good lab reports			
5. ability to work independently, in the laboratory and in the library			
6. ability to work in a team			
7. ability to integrate information learnt at different times and different places			
8. ability to think a problem through			
9. knowledge of the subject matter taught in this programme at this level			
10. oral presentation skills			
11. oral communication skills			
12. library skills			
13. ability to evaluate the proposals, performances, and ideas of peers in their written and oral reports			
Additional objectives which you consider important:(please specify)			

Rate the above learning objectives according to the following criteria. Please read the criteria carfully.

i) the degree to which they they ought to be pursued (and possibly be achieved) by the Molecular Biology and Biotechnology programme in general;
Enter the appropriate number into the left column.
(1 = no importance, 2 = minor importance, 3 = average importance, 4 = major importance, 5 = utmost importance)

ii) Now rate them according to the degree to which they they are achieved by this course, Molecular Biology 3A06.
Enter the appropriate number into the middle column.
(5 = I learned 100 % of what I wanted to learn,
4 = 80 %, 3 = 60 %, 2 = 40 %, 1 = less than 20 %)

iii) Now rate the extent to which you think the course should and could be improved to achieve each specific learning objective.
Enter the appropriate number into the right column.
(5 = no improvement possible, 4 = a little improvement possible, 3 = could be improved considerably, 2 = massive potential for improvement, 1 = any change would probably be for the better)

iv) Into the space below write specific ways in which you think that such improvements could be achieved. I.e., from your teaching experience, can you recommend any specific method by which one or more of these abilities can be taught? Use the back page if necessary.

2. SUBJECT MATERIAL

In the last two years the course emphasized, as you know, microbial Genetics and related techniques. Before that, the course emphasized general molecular experiments like Northern blotting, in vitro translation, and protein electrophoresis.
Without necessarily having experienced the former version of the course, do you consider this change in course curriculum a positive one?
Please explain the reasons for your answer.

Is there any other subject material which you consider underrepresented in the program (from your present view) and which should be incorporated into this course? You don't have to answer this if you feel not competent.

3. PROCESS

In every lab course there has to be a balance between the amounts of experimental work done as demonstration experiments by the instructor, jointly by the class, and independently by each student or labgroup.
In your opinion; was this balance in MB 3A06 appropriate, or did it it lean too much to one side?

There also has to be a balance between intellectual cooperation among students and independent work, epecially when it comes to writing lab reports.
In your opinion, was this balance in MB 3A06 appropriate, or did it it lean too much to one side?

Finally, in every programme and every course there is the dualism of theory (lectures, reading) and practise (labwork, writing).
Would you consider the Molec. Biol. Biotech. programme in general to be well balanced between theory and practise? Explain.

Would you consider this course (MB 3A06) well balanced between theory and practise?

If not, what changes would you recommend?

4. STUDENT EVALUATION

The following assignments can be used toward student evaluation: Rate each assignment in the extent to which you consider it appropriate for MB 3A06. Rate as many assignments as high or as low as you like.
(1 = not at all appropriate, 2 = not very applicable, 3 = somewhat useful, 4 = quite useful, 5 = very much appropriate)

1. written examination	
2. term paper	
3. oral examination	
4. lab reports	
5. oral presentations	
6. participation and contribution in labtalks	
7. subjective evaluation of " general participation"	

The following methods can be used in evaluating student performance:

(a) self-evaluation

(b) evaluation by peers

(c) evaluation by the instructor or TA

For the types of assignments that you rated (4) and (5) in the table above, state which evaluation method you consider most appropriate (a, b, or c).

In your opinion, who else (a group or an individual) should be contacted for additional input in this survey?

ADDITIONAL COMMENTS:

QUESTIONAIRE TYPE 3

I. LEARNING OBJECTIVES

The following is a list of learning objectives which most people consider desirable for a science programme. Instructions on what to do with it follow on the next page.

1. practical abilities and skills in lab techniques			
2. knowledge of theory behind lab techniques, and ability to apply that knowledge to the laboratory situation (e.g. for troubleshooting)			
3. ability to independently design simple experiments and controls			
4. ability to write good lab reports			
5. ability to work independently, in the laboratory and in the library			
6. ability to work in a team			
7. ability to integrate information learnt at different times and different places			
8. ability to think a problem through			
9. knowledge of the subject matter taught in this programme at this level			
10. oral presentation skills			
11. oral communication skills			
12. library skills			
13. ability to evaluate the proposals, performances, and ideas of peers in their written and oral reports			
Additional objectives which you consider important:(please specify)			

Rate the above learning objectives according to the following criteria. Please read the criteria carefully.

RATING CRITERIA:

i) the degree to which the preceding objectives ought to be pursued (and possibly be achieved) by the Molecular Biology and Biotechnology programme in general;
Enter the appropriate number into the left column.
(1 = no importance, 2 = minor importance, 3 = average importance, 4 = major importance, 5 = utmost importance)

ii) Now rate the objectives according to the degree to which you think they are achieved by this course, Molecular Biology 3A06.
Enter the appropriate number into the middle column.
(5 = students learned 100 % of what they were supposed to learn, 4 = 80 %, 3 = 60 %, 2 = 40 %, 1 = less than 20 %)

iii) Now rate the extent to which you think the course should and could be improved to achieve each specific learning objective.
Enter the appropriate number into the right column.
(5 = no improvement possible, 4 = a little improvement possible, 3 = could be improved considerably, 2 = massive potential for improvement, 1 = any change would probably be for the better)

iv) Into the space below write specific ways in which you think that such improvements could be achieved. I.e., from your teaching experience, can you recommend any specific method by which one or more of these abilities should be taught in this course?

II. CONTENT OF SUBJECT MATERIAL

In the last two years the course emphasized, as you probably know, Microbial Genetics and related techniques. Before that, the course emphasized more generally applicable molecular experiments like Northern blotting, in vitro translation, and protein electrophoresis.
Do you consider this change in course curriculum a positive one? Please explain the reasons for your answer.

Is there any other subject material which you consider underrepresented in the program (from your present view) and which should be incorporated into this course?

III. PROCESS

In every lab course there has to be a balance between the amounts of experimental work done as demonstration experiments by the instructor, jointly by the class, and independently by each student or labgroup.
According to your impression, is MB 3A06 appropriately balanced in this way, or do you see an undue overrepresentation/underrepresentation of one of the three categories?

[ ] balanced [ ] unbalanced (explain) [ ] cannot say

There also has to be a balance between intellectual cooperation among students and independent work, epecially when it comes to writing lab reports.

According to your impression, is MB 3A06 appropriately balanced in this way?

[ ] balanced [ ] unbalanced (explain) [ ] cannot say

Finally, every programme and every course has to deal with the dualism of theory (lectures, reading) and practise (labwork, writing).

Would you consider the Molec. Biol. Biotech. programme in general to be well balanced between theory and practise?

[ ] balanced [ ] unbalanced (explain) [ ] cannot say

Would you consider the MB 3A06 course well balanced in this way?

[ ] balanced [ ] unbalanced (explain) [ ] cannot say

If not, what changes would you recommend?

IV. STUDENT EVALUATION

Below are listed a number of assignments that can be used toward evaluation of student performance.
Rate each assignment in the extent to which you consider it appropriate for MB 3A06 in its current format. Rate as many assignments as high or as low as you like.
(1 = not at all applicable 2 = not very applicable, 3 = somewhat useful, 4 = quite useful, 5 = very much appropriate)

written examination		
term paper		
oral examination		
lab reports		
oral presentations		
participation and contribution in labtalks		
subjective evaluation of "general participation" (attendance, motivation, labskills, etc.)		

The following methods can be used in evaluating student performance:

(a) self-evaluation

(b) evaluation by peers

(c) evaluation by the instructor or TA

For the types of assignments that you rated (4) and (5) in the table above, state which evaluation method you consider most appropriate (a, b, or c). Enter the letters into the column on the right.

V.

The following persons have been contacted in this survey:

- Students who registered in MB 3A06 in 1989 or 1990;
- Graduate students who TAed the course in 1989 or 1990;
- Drs. Prevec, Finan, Bayley, as faculty representatives;
- A few prospective graduate supervisors and/or employers;

In your opinion, who else (a group or an individual) should be contacted for additional input in this survey?

Thank you again for your input.

ADDITIONAL COMMENTS:

MOLECULAR BIOLOGY 3A06

Laboratory in Molecular Biology

Term II Section
1990-91

T.M. Finan
A. Lautensach
Term I-Biochemistry Dept.

The objective of this course is to introduce the students to some of the types of experiments that they might encounter in a career in molecular biology, with a focus on microbial genetics and biotechnology.

The course is divided into three parts. Part one focuses on bacterial genetics, including transposon mutagenesis, various means of mutant characterization, and the screening of a genomic library. Part two focuses on molecular cloning, including large-scale plasmid preparations and restriction mapping. Part three focuses on molecular genetics of yeast, including transformation, plasmid preparation, and heterologous expression.

The course does not include a formal lecture. Instead, frequent discussions and presentations of results will encourage self-directed learning of the necessary background.

Evaluation:	**Lab reports**	**approximately**	**50%**
	Final exam	**"**	**40%**
	Overall performance	**"**	**10%**

Prerequisite: Credit or registration in one of Biochemistry 3A06, 3B03, 3G06, and registration in Honours Molecular Biology and Biotechnology; or permission of the instructor.

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QUESTIONAIRE TYPE 4

(Prospective graduate student supervisors / Employers)

I. LEARNING OBJECTIVES

The following is a list of learning objectives which most people consider desirable for a science programme. Some of these you probably take into consideration when you screen applicants for prospective graduate students or employees. Instructions on what to do with this list follow on the next page.

1. practical abilities and skills in lab techniques		
2. knowledge of theory behind lab techniques, and ability to apply that knowledge to the laboratory situation (e.g. for troubleshooting)		
3. ability to independently design simple experiments and controls		
4. ability to write good lab reports		
5. ability to work independently, in the laboratory and in the library		
6. ability to work in a team		
7. ability to integrate information learnt at different times and different places		
8. ability to think a problem through		
9. knowledge of the subject matter taught in this programme at this level		
10. oral presentation skills		
11. oral communication skills		
12. library skills		
13. ability to evaluate the proposals, performances, and ideas of peers in heir written and oral reports		

Additional objectives which you
consider important:(please specify)

i) Rate the items on this list according to the weighting you use when screening prospective graduate students or technician. Enter the appropriate number into the column on the left.
(1 = no importance, 2 = minor importance, 3 = average importance, 4 = major importance, 5 = utmost importance)

ii) Rate items on this list according to their importance for a third year laboratory course in Molecular Biology. Enter the appropriate number into the column on the right.
(1 = no importance, 2 = minor importance, 3 = average importance, 4 = major importance, 5 = utmost importance)

What other abilities do you look for in a prospective graduate student or employee?

In your opinion, can these other abilities be taught in the third year of a programme in Molecular Biology?

[ ] probably [ ] probably not [ ] cannot say

II. CONTENT OF SUBJECT MATERIAL

In the last two years the course emphasized microbial Genetics and related techniques. Before that, the course emphasized more generally applicable molecular experiments like Northern blotting, in vitro translation, and protein electrophoresis.
Since you may not be sufficiently familiar with the Molecular Biology and Biotechnology programme at McMaster I won't ask you about your preference of subject material in this particular course.
Instead, I am asking you to consider the sum of all laboratory courses in any Molecular Biology and Biotechnology programme. For each of the following categories, check what items you consider indipensable in the laboratory curriculum (in addition to basic laboratory courses in Biology and Biochemistry):

Experiments in the following subject areas :

	indispensable	useful but not essential
microbial taxonomy	☐	☐
immunology	☐	☐
cell physiology and metabolism	☐	☐
fermentation technology	☐	☐
virology	☐	☐
plant biotechnology	☐	☐
process engineering	☐	☐
mycology	☐	☐
nutrition	☐	☐
health and medical science	☐	☐
environmental science	☐	☐
histology	☐	☐
others (please specify):	☐	☐

Personal experience with the following experimental technology:

DNA restriction mapping	☐	☐
mammalian cell culture	☐	☐
ultracentrifugation	☐	☐
electrophoresis and blotting techniques	☐	☐
monoclonal antibodies	☐	☐
liquid chromatography	☐	☐
distillation and fermentation monitoring	☐	☐
basic microbiological techniques	☐	☐
genetic mapping by recombination	☐	☐
liquid scintillation counting	☐	☐

mutagenesis	☐	☐

Working experience with the following biological specimens:

Bacteria	☐	☐
Fungi	☐	☐
Cultured animal cells	☐	☐
Whole animals	☐	☐
Cultured plant cells	☐	☐
Whole plants	☐	☐
Viruses	☐	☐

III. PROCESS

In every lab course there has to be a balance between the amounts of experimental work done as demonstration experiments by the instructor, jointly by the class, and independently by each student or labgroup.
Fill in the optimal time distribution for the average third year lab course in a Molecular Biology programme, as percent labtime spent on each category:

	% of total labtime
Demonstrations by the instructor	☐
Experiments done jointly by the class	☐
Experiments done individually or in groups	☐

There also has to be a balance between intellectual cooperation among students and independent work, epecially when it comes to writing lab reports.
Give the optimal distribution of the total workload of written assignments for the average third year lab course in a Molecular Biology programme:

% of total workload
in written assignments

Assignments carried out in cooperation	☐
Assignments carried out individually	☐

Cannot specify because distribution depends on the subject matter and/or other variables: ☐

Finally, every programme and every course has to deal with the dualism of theory (lectures, reading) and practise (labwork, writing).
Give the optimal distribution of the total worktime spent by the students for the average third year lab course in a Molecular Biology programme:

% of total worktime

Background lectures	☐
Background reading	☐
Experiments	☐
Lab report writing	☐
Lab meetings and discussions	☐

Cannot specify because distribution depends on the subject matter and/or other variables: ☐

IV. STUDENT EVALUATION

Below are listed a number of assignments that can be used toward evaluation of student performance.
Rate each assignment in the extent to which you consider it appropriate for the average third year lab course in a Molecular Biology programme. Rate as many assignments as high or as low as you like.
(1 = not at all applicable 2 = not very applicable, 3 = somewhat useful, 4 = quite useful, 5 = very much appropriate)

written examination		
term paper		
oral examination		
lab reports		
oral presentations		
participation and contribution in labtalks		
subjective evaluation of "general participation" (attendance, motivation, labskills, etc.)		

Cannot specify because emphasis depends on the subject matter and/or other variables: ☐

The following methods can be used in evaluating student performance:

(a) self-evaluation

(b) evaluation by peers

(c) evaluation by the instructor or TA

For the types of assignments that you rated (4) and (5) in the table above, state which evaluation method you consider most appropriate (a, b, or c). Enter the letters into the column on the right.

V.

The following persons have been contacted in this survey:

- Students who registered in MB 3A06 in 1989 or 1990;
- Graduate students who TAed the course in 1989 or 1990;
- Drs. Prevec, Finan, Bayley, as faculty representatives;
- A few prospective graduate supervisors and/or employers;

In your opinion, who else (a group or an individual) should be contacted for additional input in this survey?

Thank you again for your input.

ADDITIONAL COMMENTS:

MOLECULAR BIOLOGY 3A06

Laboratory in Molecular Biology

Term II Section
1990-91

T.M. Finan
A. Lautensach
Term I-Biochemistry Dept.

The objective of this course is to introduce the students to some of the types of experiments that they might encounter in a career in molecular biology, with a focus on microbial genetics and biotechnology.

The course is divided into three parts. Part one focuses on bacterial genetics, including transposon mutagenesis, various means of mutant characterization, and the screening of a genomic library. Part two focuses on molecular cloning, including large-scale plasmid preparations and restriction mapping. Part three focuses on molecular genetics of yeast, including transformation, plasmid preparation, and heterologous expression.

The course does not include a formal lecture. Instead, frequent discussions and presentations of results will encourage self-directed learning of the necessary background.

Evaluation:	Lab reports	approximately 50%
	Final exam	" 40%
	Overall performance	" 10%

Prerequisite: Credit or registration in one of Biochemistry 3A06, 3B03, 3G06, and registration in Honours Molecular Biology and Biotechnology; or permission of the instructor.

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Area Courses:
Mathematics 2E03, 2G03, 2J06, 2K03, 2O03; Computer Science 2ME3, 2P03, 3P03; Statistics 2D03, 2M03; all Level III Mathematics and Statistics courses.

Levels II and III: 60 units
R Mathematics 2G03, 2J06, 2O03, 3O06; one of Mathematics 3B03, 3E03, 3T03; 6 units of Area courses.
E Electives to make a total of 60 units, at least 12 units of which must not be from the Department of Mathematics and Statistics.

Molecular Biology and Biotechnology

HONOURS MOLECULAR BIOLOGY AND BIOTECHNOLOGY
This Honours degree programme is administered within the Faculty of Science, jointly by the Departments of Biochemistry, Biology and Pathology, through a Committee of Instruction. The programme also draws on the McMaster Institute for Molecular Biology and Biotechnology. Information and counselling may be obtained from the Programme Co-ordinator, Dr. S.T. Bayley in the Department of Biology.

Admission:
Completion of **Natural Sciences I** including Biology 1A06, Chemistry 1A06, one of Physics 1A06, 1B06, or 1C06, with at least a B− in Biology 1A06, Chemistry 1A06, and in one of Mathematics 1A06, 1C06 or Physics 1A06, 1B06, 1C06. The inclusion of Computer Science 1MA3 or 1ZA3 in Level I is strongly recommended.

Programme Note:
Level IV programme registrations must be approved by the Programme Co-ordinator for Molecular Biology and Biotechnology.

Area Courses:
Biochemistry 2A03, 3A06, 3B03, 3C03, 3G06, 4B06, 4I03, 4M03, 4P03, 4Q03; Biology 2B03, 2C03, 2D03, 2E03, 3E03, 3H03, 3HH3, 3N06, 3O03, 4B03, 4C08, 4F04, 4H03, 4I03, 4V03; Chemistry 2B06, 2N03, 2O06, 2Q06, 3D03; Molecular Biology 3A06, 4A03, 4B03, 4C03, 4D03, 4E03, 4F03, 4G03.

Level II: 30 units
R Biochemistry 2A03; Biology 2B03, 2C03; Chemistry 2O06, 2Q06; Computer Science 1MA3 or 1ZA3 (if not completed); one of Biology 2D03, 2E03, Chemistry 2N03.
E 3 to 6 units. Biology 2D03, 2E03, Chemistry 2N03 are recommended if not taken in the R group.

Level III: 30 units
R Biochemistry 3A06 or 3G06 (if Biochemistry 2A03 not completed); Molecular Biology 3A06; Biology 3H03, 3N06, 3O03; Chemistry 3D03.
E 3 units.

Level IV: 30-32 units
R Either Molecular Biology 4A03 and one of Biochemistry 4P03, Biology 4F04, or one of Biochemistry 4B06, Biology 4C08; Molecular Biology 4B03, 4C03, 4D03; 9 units chosen from Biochemistry 4I03, 4M03, 4Q03; Biology 4H03, 4I03, 4V03; Molecular Biology 4E03, 4F03, 4G03.
Students who have opted in either Biochemistry 4B06 or Biology 4C08 for a thesis topic which is outside the Molecular Biology discipline will be required to take Molecular Biology 4A03.
E 6 units.

Department of Physics

HONOURS CHEMISTRY AND PHYSICS
(See Department of Chemistry)

HONOURS GEOLOGY AND PHYSICS
(See Department of Geology)

HONOURS MATHEMATICS AND PHYSICS
(See Department of Mathematics and Statistics)

HONOURS ARTS AND SCIENCE AND PHYSICS (B.Arts Sc.)
(See Arts and Science Programme)

HONOURS PHYSICS
Admission:
Completion of **Natural Sciences I**, including Mathematics 1A06 and 1B03, Physics 1A06 and Chemistry 1A06, with a weighted average of at least 7.0 in the Physics and Mathematics courses. Students will also be considered for admission if they have completed Physics 1B06 or 1C06, instead of 1A06. However, Physics 1A06 is *strongly recommended*. It is also recommended that Computer Science 1MA3 be taken in Natural Sciences I.

Programme Note:
Students who have completed Level II of Honours Physics are eligible to proceed to Level III of Honours Physics, and Honours Applied Physics. They may also be considered for admission to Level III of Honours Materials Science, preferably if Materials 1A06 or 1A03 and 1B03, or Engineering 2003, has been completed in Level II.

Area Courses:
Physics 2B06, 2C05, 2H03, 3A03, 3B06, 3H04, 3K04, 3M03, 3MM3, 3M06, 3N03, 3X03, 3Y03, 4A02, 4B04, 4C03, 4D06, 4E03, 4F03, 4G03, 4J04, 4K03, 4U03; Mathematics 2A06, 3C03, 3D03.

Level II: 32-35 units
R Physics 2B06, 2C05, 2H03; Mathematics 2A06, 2C03; Computer Science 1MA3 (if 1B03 not completed).
E Electives to make a total of 32 to 35 units, at least 6 of which must not be from Physics.

Level III: 32-35 units
R Physics 3H04, 3K04, 3M03, 3MM3, 3N03; Mathematics 3C03, 3D03; 3 to 6 units of Level III or IV courses from the Faculty of Science. At least one of Physics 3B06 or 4D06 must be completed in either Level III or IV. Students will generally find that more choices are offered by the timetable if Physics 3B06 is taken in Level III and if Physics 4D06 is taken in Level IV.
E 6 units, excluding Physics and Engineering Physics.

Level IV: 31-34 units
R Physics 4A02, 4B04, 4F03, 4J04; two of Physics 3A03, 3X03, 3Y03, 4C03, 4D06, 4E03, 4K03; 6 units of Level III or IV courses from the Faculty of Science.
E Electives to make a total of 31 to 34 units.

HONOURS PHYSICS (THEORY OPTION)
Admission:
Completion of **Level II Honours Physics** or **Level II Honours Mathematics and Physics**.

Area Courses:
Applicable Level II Area courses; Physics 3A03, 3H04, 3K04, 3M03, 3MM3, 3N03, 3X03, 3Y03, 4A02, 4B04, 4C03, 4E03, 4F03, 4G03, 4K03, 4Q04, 4U03; Mathematics 3C03, 3D03, 3Q03, 4O03, 4V03.

Level III: 32-35 units
R Mathematics 3C03, 3D03, 3Q03; Physics 3H04, 3K04, 3M03, 3MM3, 3N03, 4C03 (if offered). NOTE: Physics 4C03, which is offered in alternate years, must be taken in Level III or Level IV.
E 6 to 9 units, at least 3 of which must be from outside of Physics and Engineering Physics.

Level IV: 31-34 units
R Mathematics 4O03; Physics 4A02, 4B04, 4C03 (if not completed), 4F03; 9 units from Physics 3A03, 3X03, 3Y03, 4E03, 4G03, 4K03, 4U03; 6 units of Level III or IV courses from the Faculty of Science. NOTE: Physics 4C03, which is offered in alternate years, must be taken in Level III or Level IV.
E Electives to make a total of 31 to 34 units.

HONOURS APPLIED PHYSICS
Admission:
Completion of **Level II Honours Physics**, or **Level II Honours Mathematics** including Physics 2B06 and 2C05.

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