

## **Managing the delivery of ‘Manufacturing Processes’ in an Australian Regional University known for excellence in e-learning**

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**Abstract:** The aim of this paper is to share the author’s experience in managing the delivery of the course, *Manufacturing Processes*, in the Bachelor of Engineering (Mechanical), Bachelor of Engineering (Mechatronics), Bachelor of Engineering Technology (Mechanical) and Associate Degree (Mechanical) programs offered by the University of Southern Queensland (USQ), a regional Australian University excellence in developing e-learning (Good University Guides, 2000). USQ is also a regional university with campuses in Toowoomba, Fraser Coast and Springfield, Queensland. The paper starts with defining the contents of the course. The mode of delivery as well as the on-going modifications to the contents of the course is mentioned. A comparative study on e-learning against traditional learning was also deeply discussed with particular reference to *Manufacturing Processes*. It was concluded that the management of the delivery had been not too bad in this regional university with limited resources.

**Keywords:** manufacturing processes, academic courses, practical courses, off campus, forming operations and cutting operations.

### ***Introduction***

In USQ, ‘Manufacturing Processes’ is offered as the core course to four mechanical engineering degree programs. It is a one-semester course and is only offered once per year. In addition, the course is also offered as on-campus study as well as print based

delivery, in which study books and other materials, e.g. CD-ROM are mailed to the students worldwide via courier. Additional supports given to off-campus students include communication by telephone, e-mails and WebCT as the Learning Management System through Internet (USQ Handbook, 2005). The on-campus and off-campus modes are offered in the same semester. For the on-campus study, the course is currently available only in Toowoomba campus.

The Bachelor of Engineering (Mechanical or Mechatronics) at USQ is a four-year full-time or part-time equivalent degree program which leads to a career as a *Chartered Professional Engineer*. The program consists of 32 academic courses and 7 practical courses (Morgan et al., 1999). The Bachelor of Engineering Technology (Mechanical) at USQ is a three-year full-time or part-time equivalent degree program which leads to a career as a *Chartered Engineering Technologist*. The program consists of 24 academic courses and 5 practical courses. The Associate Degree in Engineering (Mechanical) at USQ is a two-year full-time or part-time equivalent degree program which leads to a career as a *Chartered Engineering Officer*. The program consists of 16 academic courses and 4 practical courses (Morgan et al., 1999).

The three groups of students are required to study the same level course, 'Manufacturing Processes' because of the scale of economy. In the past, USQ did offer a separate course, *Manufacturing Processes and Materials* for students of Associate Degree in Engineering (Mechanical) program. As the number of such students fell to an extremely low level, there was no option except to make them study the same course, *Manufacturing Processes* as other students of Mechanical Engineering programs. The total number of the students for the course varies from

one year to the other but it ranges from 45 – 60 for internal students and ranges 35- 50 for external students, of which around 5 (on campus) and around 10 (off-campus) will be the students of Associate Degree in Engineering (Mechanical) program and around 15 (on campus) and around 10 (off-campus) will be those of Bachelor of Engineering Technology (Mechanical) program. USQ would not like to stop offering the Associate Degree (Mechanical) program which is well articulated to Bachelor of Engineering Technology (Mechanical) program and many of the students of Bachelor of Engineering Technology (Mechanical) program are the former students of the Associate Degree (Mechanical) program, which require students to study only 8 more academic courses and one practical course for the award of Bachelor of Engineering Technology (Mechanical).

The academic standing and ability of the students of the two programs, Bachelor of Engineering (Mechanical) and Bachelor of Engineering (Mechatronics) are more or less at par. Their entry requirements are the same. However, those of Bachelor of Engineering (Mechanical), Bachelor of Engineering Technology (Mechanical) and Associate Degree (Mechanical) are generally at three different levels. Their entry requirements are different with Bachelor of Engineering (Mechanical) requiring highest score and Associate Degree (Mechanical) the lowest one. The contents of the course need to satisfy the aspirations of the three groups of students as well as the stringent requirements set by our accrediting body, The Institution of Engineers, Australia (Engineers Australia, 2004a; 2004b).

### ***Courseware***

The course is divided into two parts, with Part A being Forming Operations and Part B being Cutting Operations. In the print-based delivery, the two parts are split into two study books. The topics in Part A, Forming Operations consist of ‘Manufacturing Costs’, ‘Casting Processes’, ‘Forming Processes’, ‘Powder Metallurgy’, ‘Forming of Plastics, Ceramics and Composites’, ‘Welding Processes’ and ‘Rapid Prototyping’. The modules in Part B, Cutting Operations contain ‘Principles of Metal Cutting’, ‘Cutting Tools’, ‘Turning, Boring, Drilling and Related Processes’, ‘Milling, Broaching and Sawing Processes’, ‘Abrasive Machining Processes’, ‘Form Generation Processes’ and ‘Non-traditional Machining Processes’ (Ku and Morgan, 2005; Ku and Boundy, 2005).

The contents of the course are modified continually to meet the new accreditation requirements by the Institution of Engineers, Australia, the aspirations of our students and the demands of the job market. One recent example is the removal ‘CNC Machining’ and ‘Jigs and Fixtures’, and the addition of ‘Rapid Prototyping’. All the contents of the ‘CNC Machining’ were incorporated into a practical course, ‘Mechanical Practice 3’ to ensure the smooth running of the latter course.

### ***Distance and e-Learning Centre (DeC), USQ***

Having prescribed and written down the teaching materials, the examiner passes the materials to the moderator for moderation. The materials are then passed to the DeC for further processing. As well as being the 'production house' for the design, development, production, and distribution of USQ study materials, including the e-

learning materials, DeC provides a range of services to specifically meet the needs of academic staff involved in teaching and learning activities across the University. Most courses of study have three items in each learning package: an introductory book; a study book; and a book of selected readings. Many learning packages also include other items such as computer managed assessment (CMA), audio or videotapes, books of worked solutions and computer disks.

Figure 1 shows the course development process in DeC, University of Southern Queensland (USQ, 2006). The production process starts with *Planning and Scheduling*. Scheduling begins a year in advance of the actual teaching period. Submission dates are determined by the change cycle (new, major, minor or no change). Tracking information is available on a campus-wide materials database which covers learning packages from the planning phase to the dispatch phase.

### ***Format of Study Books***

It is worth mentioning that the study books for this course have been written for both on-campus and off-campus students. The cost of the two books plus an 'Introductory Book' with two assignments for the course is only 15 Australian dollars; the off-campus students will receive them free from the USQ Distance and e-Learning Centre (DeC) via couriers and it would not cost too much to internal students. In the study books, diagrams and figures are usually used to explain processes with as little words as possible. This is to make teaching and learning more effective and direct. If the students were still unable to grasp the main points or concepts of a topic from reading the study book or lecture, they will then be advised to read the relevant chapter in the

recommended text book, which is also required if students wish to know more and get higher grades in the overall assessment of the course.

### ***Teaching Strategy***

In on-campus delivery, the material (contents) is delivered in 2 (Part A and Part B) x 13 lectures and 2 (Part A and Part B) x 13 tutorials; the duration for each lecture or tutorial is one hour. The total number of hours a student expected to successfully complete the course is 155 hours which also include 3-hour examination and 94-hour private study. The first problem faced with teaching this course in a regional Queensland's university, whether it is to on-campus or off-campus students, is to include material that will suit the three different groups of students. In general, the middle academic ability group, Bachelor of Engineering Technology (Mechanical) should be targeted.

The details of each module in the course have to be carefully examined and selected. By and large, the contents of Part A of the course, Forming Processes, are more descriptive as it is more difficult for students, particularly, Associate Degree (Mechanical) program students to conceptualize the quantitative contents of the topics. There are a lot more quantitative contents in Part B of the course, particularly in the topics of 'Principles of 'Metal Cutting', 'Cutting Tools', 'Turning, Boring, Drilling and Related Processes', and 'Milling, Broaching and Sawing Processes'. Another problem for the face-to face teaching of the course is to provide adequate machine tools for the students to practice. USQ has a small mechanical workshop used mainly for making the hardware of undergraduate and postgraduate student projects as well as simple mechanical maintenance and repair within the Faculty of Engineering and Surveying. Students do have the opportunity to make simple

components using lathes and milling machine in a group of three in one of their practical course, Mechanical Practice One; the time spent on the two machines will be four hours. Furthermore, students do have the chance to make sand moulds in a small group in another practical course, Engineering Practice One. This exercise is very useful to two of the modules in Part B and two modules in Part A of the course.

A large proportion of the on-campus students are school leavers and they will have very little chance to view all the equipment and machine tools mentioned in the modules of the course. The best way to make them familiar with the equipment and machine tools and how they operate is to train them to use the facilities but this can only be done limitedly in USQ because of the resources problems. Some way has to be found to provide the necessary knowledge to the students about the equipment and machine tools and how they operate. To solve this problem, in a 60-minute lecture, thirty five to forty minutes will be used to deliver lecture with diagrams and figures using overhead projector and transparencies or power point. This will make the students understand how the processes are carried out or the external features and the operations of machine tools. The remaining twenty to twenty five minutes will be used by showing them short videos to improve their understanding about the topics.

The 60-minute tutorial is normally divided into three different activities. Tutorial will start with asking students to solve some problems like designing a die assembly for press tool; this will last for about thirty five minutes. Students will solve the problem on their own for the first twenty five to thirty minutes while the tutor will wander around to see if help is required. The last five minutes will be used to deliver the suggested solutions and students will be given printed answers for solutions requiring

a lot of time to copy down, e.g. designing a die assembly. The remaining time will be used to show some relevant videos.

Interaction between lecturer and students is the most significant problem faced with the print-based delivery mode. Students normally receive the information about the course through reading the study books. If students have difficulty in understanding the study material, they can pause and read the relevant information in the text book and hope that the differently written material in the text book can improve their understanding of the topic; if this fails, students cannot raise their hand and ask the lecturer immediately. Students can, however, ring their lecturer and ask for help but this may not work satisfactorily as the lecturer can be in the class or some other commitments outside his/her office. If the contact fails, students will have spent a lot of unnecessary money on the phone call. The next option is for students to send an e-mail to the staff to clarify these questions but this will lead to delay in getting the required answer, perhaps by as much as 24 hours. This will obviously slow down the progress of their learning but it has been a significant improvement of print-based delivery mode in the last decade because of this technology.

### *Assessments*

There are three assessments for the course; two assignments, one from each part, with a weight of 15 % each will be given to students with their 'Introductory Book'. The first assignment is from Part A of the course and contains two questions, one of which will be 'Casting Processes' and the other 'Manufacturing Costs'. Both topics will be covered within the first five weeks of the semester and students are expected to hand in their first assignment at the starting of week 8. The second assignment will be



from Part B of the course and consists of three questions; questions will come from three of the four modules: 'Principles of Metal Cutting', 'Cutting Tools', 'Turning, Boring, Drilling and Related Processes', Milling, Broaching and Sawing Processes'. These topics will be covered within the first nine weeks of the semester and students are expected to hand in their second assignment at the starting of week 12. Both assignments will be marked by the lecturer and returned to students within 7 working days. Suggested solutions with marking schemes will also returned to students with the marked assignments. External students hand in their assignments by mail via the USQ Distance and e-Learning Centre and will be returned via the same pathway. Students will need to spend three hours for each assignment and these six hours have been included in the 94-hour private study.

The last assessment is a 3-hour restricted examination which consists of two parts, A and B. There are four questions from each part and students are requested to attempt a total of five questions with at least two questions from each part. Students with better knowledge in quantitative problems are expected to attempt three questions from Part B while the others are expected to attempt two questions from this part and three questions from the other.

### ***Discussion***

In on campus mode, class discussions promote reflection and further exploration of issues and topics. Discussions are a valuable method of learning through interactions with others. Thanks to modern technology, discussions can now be used for distance or online students. Learners can participate discussions to share their experience and prior knowledge through a platform (WebCT in USQ). Online discussions have two

advantages over on-campus ones. First, there is no time limit for the discussions; students can have time to do research and explore issues before they respond to a question or comment. Second, the students do not know each other and they do not need to face each other so students are more willing to express their views even the shy ones can do this.

In online teaching and delivery, a considerable amount of time has to be spent to design, develop and modify curriculum as well as implementing alternative teaching methods and assessment. The role of lecturer shifts from content provider to content facilitator; she or he must also be comfortable in using the Web as the primary lecturer-student link (Lim, 2001; DeVries and Lim, 2003). *Manufacturing Processes* is better in the sense that it is delivered as distance education and not online; this means that only studybook, introductory book and text book will be required. Time required to design, develop and modify curriculum is less. Also, the role of lecturer is still mainly content provider but she or he must be proficient in using Web technology. Furthermore, there are various means of supporting online and distance education teaching in terms of providing learning guides, online tutors and study centre for group learning and computer facilities. In *Manufacturing Processes*, studybook, introductory book, regional liaison officer and study centre, e.g. Brisbane Study Centre, are provided for distance education as well as face-to-face students.

There are three types of interaction necessary for successful distance and online education: 1) learner-content interaction, 2) learner-lecturer interaction and 3) learner-learner interaction. For on campus students, there is no difficulty in providing the three types of interactions but online or distance education lecturers need to ensure

that all forms of interactions are maximized in their course structure. For *Manufacturing Processes*, the first type of interaction is provided by studybook and introductory book as well as a textbook; the other types of interactions are provided through WebCT (Moodle in the future) (DeVries and Lim, 2003).

In distance or online education, students have to learn new communication strategies, e.g. WebCT and Internet and help has to be provided for them in learning the new communication strategies to ensure they are comfortable with the use of the modern delivery methods. An educationalist suggested that one effective way is to pair/group students during the first lesson of a course. This will make students become adept at communicating one-on-one with another student and provides a bridge to communicating in a whole class discussion. In *Manufacturing Processes*, this has not been achieved and suggestions have to be made to higher management to implement this as there will be additional resource implication (DeVries and Lim, 2003).

In the web environment, there are a number of advantages and educational opportunities over on-campus teaching such as using online databases. However, it is important that the lecturers make students learn the skills to differentiate reliable information from the vestiges as the information in the Internet is mostly not reviewed. This will be implemented in *Manufacturing Processes* in 2008 (DeVries and Lim, 2003).

Renowned speakers residing at a distance can be invited as guest lecturers to participate in online discussions with students studying on campus. This can be

accomplished by adding online component to face-to-face students. This will hopefully be implemented in *Manufacturing Processes* in 2008 (DeVries and Lim, 2003).

Other advantages of online or distance education classes result from the medium itself. In online discussion, the emphasis is on the use of written words and students are encouraged to a deeper level of thinking. The fact that students are required to write their thoughts down will make students understand their views better before discussing them with others. Students and lecturers can read a posting and consider their response for a day or so before posting it. Because of time constraint, only limited number of students can participate in discussions. With only 50 or so on-campus students in *Manufacturing Processes*, this problem always emerges. There will be more equality between students and lecturers in an online environment. The lack of face-to-face persona seems to disarm the lecturer of some authority. In on-campus mode, the lecturer initiates the action while in off-campus mode, the students initiate the action by going to the web site, posting a message or doing something. Students may sometimes be aggressive and ask some questions in ways not seen in face-to-face environment (DeVries and Lim, 2003).

Some educators claimed that in some cases, face-to-face teaching is a 'must' like chemistry or physics laboratories. This may not be completely true as the use of machine tools in *Manufacturing Processes* can be demonstrated to students through videos. As distance educators always try to find ways to ease communication for online teaching, they also tend to agree that a combination of face-to-face and virtual contact is the optimum, particularly for courses awarding degrees. This is exactly

what USQ is doing; USQ encourages mixed mode, some on-campus courses plus some off-campus ones. This university is very flexible about this with a view to facilitating the working, family and learning commitment of students. However, this cannot be easily achieved in this vast (Australia) but sparsely populated country (DeVries and Lim, 2003).

One of the authors did teach similar course at diploma level in a technical institute in Hong Kong for more than 10 years (full-time and part-time combined). The students in Hong Kong had their workshop practice in parallel with the academic course of manufacturing technologies. They would have the experience of operating traditional machine tools, e.g. lathes, milling, grinding and drilling machines. On account of the level of the course, most of the contents were qualitative. Once students had seen and operated the machines, they would have no difficulty in understanding the academic course but their problem was English as the medium of instruction was English. However, when some special machines like gear hobbing and broaching machines were discussed, students were required to watch films about the machines to increase their understanding about how the machines were operated. In addition, plastic processing machines like injection, blow and vacuum molding machines had to be introduced to students through films. Therefore viewing videos or films in teaching manufacturing technologies was not peculiar to USQ. Many of my colleagues in Hong Kong had to ask their students to view films when they taught special machining processes.

With viewing relevant videos and limited workshop practice in manufacturing technology, it can be argued that the course, *Manufacturing Processes*, has been

successfully delivered in this regional university because our four programs are in mechanical engineering and not manufacturing or industrial engineering. Local employers also do not criticize the knowledge in manufacturing processes of our graduates.

In order to improve retention rate, students, both on-campus and off-campus, who did not submit their assignments in time will receive an e-mail from the lecturer to ask them to react to the e-mail within 3 working days if they still wish to have their assignments marked. Students are encouraged to hand in their assignments but some marks may be deducted due to late submission. Telephone calls will also be made to those who did not respond to the e-mail by the lecturer after three days. The calls are to encourage them to hand in their assignments as quickly as possible but they will be told that some marks may be deducted because of late submission. Students who respond to the e-mail are more positive as they are more likely to hand in their assignments; students who are called are not so positive and it is difficult for the lecturer to persuade them to hand in their assignments.

Finally, it will be illustrated that the delivery of the course is not isolated; it has to be related to some of the courses in engineering degree programs. Figure 2 illustrates how *Manufacturing Processes* is linked with other courses in the materials and manufacturing stand. Engineering Materials is the pre-requisite for the course, *Manufacturing Processes*; on the other hand, the preferably co-requisites of it are Materials Technology and Production Engineering. Engineering Management and

Engineering Management are related to the course, but they can be studied independently (Ku and Morgan, 2005).

The demand for distance education is accelerating across Australia, with some universities reporting a 50 per cent increase of course enrolments during the past two years. Higher education leaders attribute the increase partly to more courses becoming available online and the availability of FEE-HELP loans from the Commonwealth Government of Australia. There has been an increase in demand for distance education in a broader sense that has come about by the electronic boom. People can go online to do their courses, have discs sent to them, not even need paper, and universities are making more courses available online. City people can now also take distance education courses when lecture and tutorial times do not fit their pattern, making it easy for them.

Gone are the days when distance education was primarily done by people living in remote and regional areas. These days more and more people in metropolitan areas are turning to it. Most people doing our distance education courses are working, many have families and want to be able to study off-campus and in their own time to enhance their career. The market for postgraduate courses is very strong, and distance education gives students the ability to study in their own time and place. Students choose a mix of internal and external study because of the flexibility that online distance education now provides (Lockhart, 2006).

### ***Conclusion***

Despite great difficulty, the off-campus and on-campus delivery of the course have been improving over the past twelve years; this is particularly true with off-campus,

international offering. The course has attracted more and more students from Singapore, Hong Kong and Malaysia, particularly from students studying for Bachelor of Engineering, which has been accredited by Engineers Australia as satisfying the academic requirements for Chartered Professional Engineer.

The strategy of showing videos about manufacturing processes to on-campus students should be considered best when there is not enough machine tools or equipment to show processes in action and this is encouraged by the fact that in the latest edition of the prescribed text written by Groover (2007), a CD-Rom containing video clips about machining processes has been included in the book.

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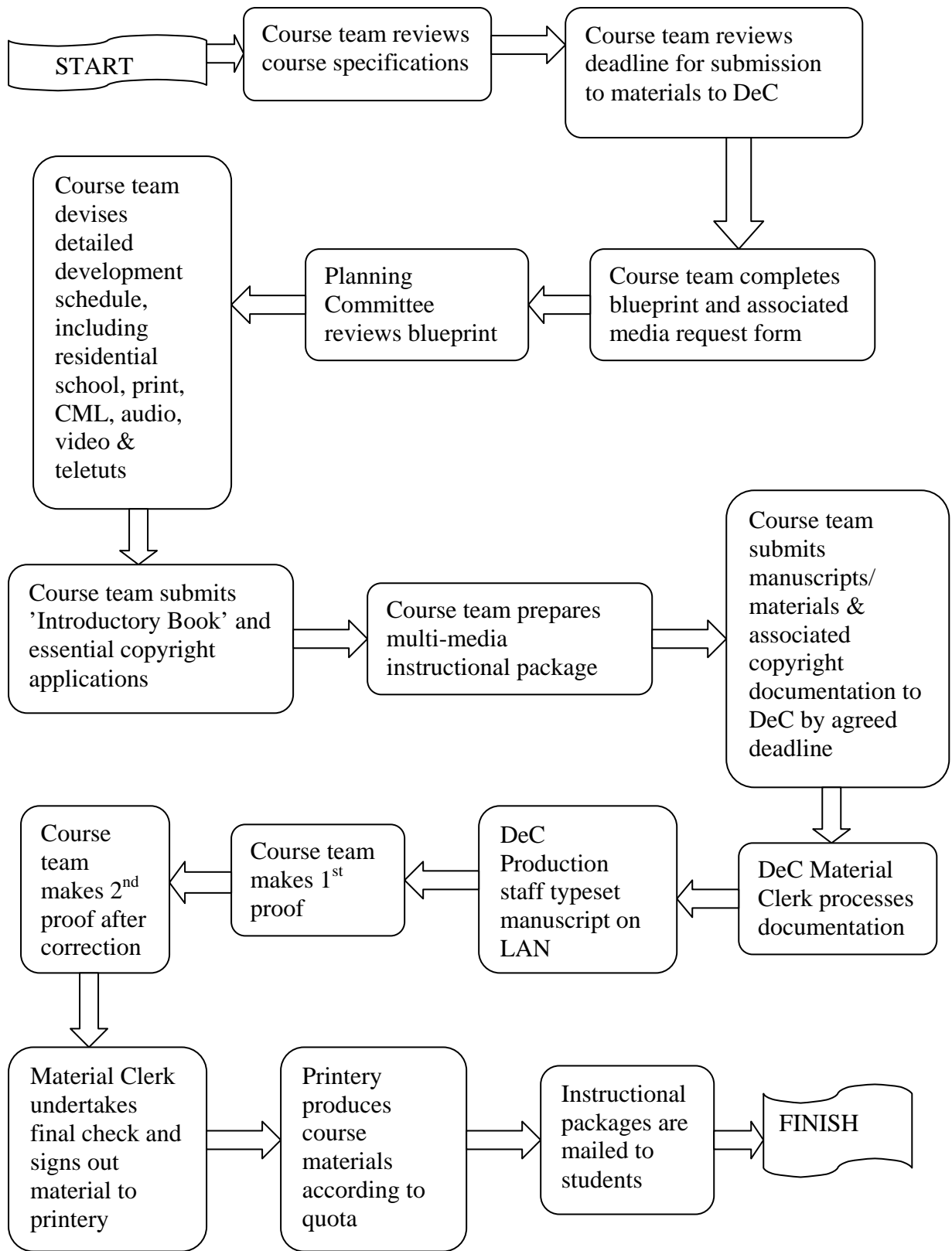
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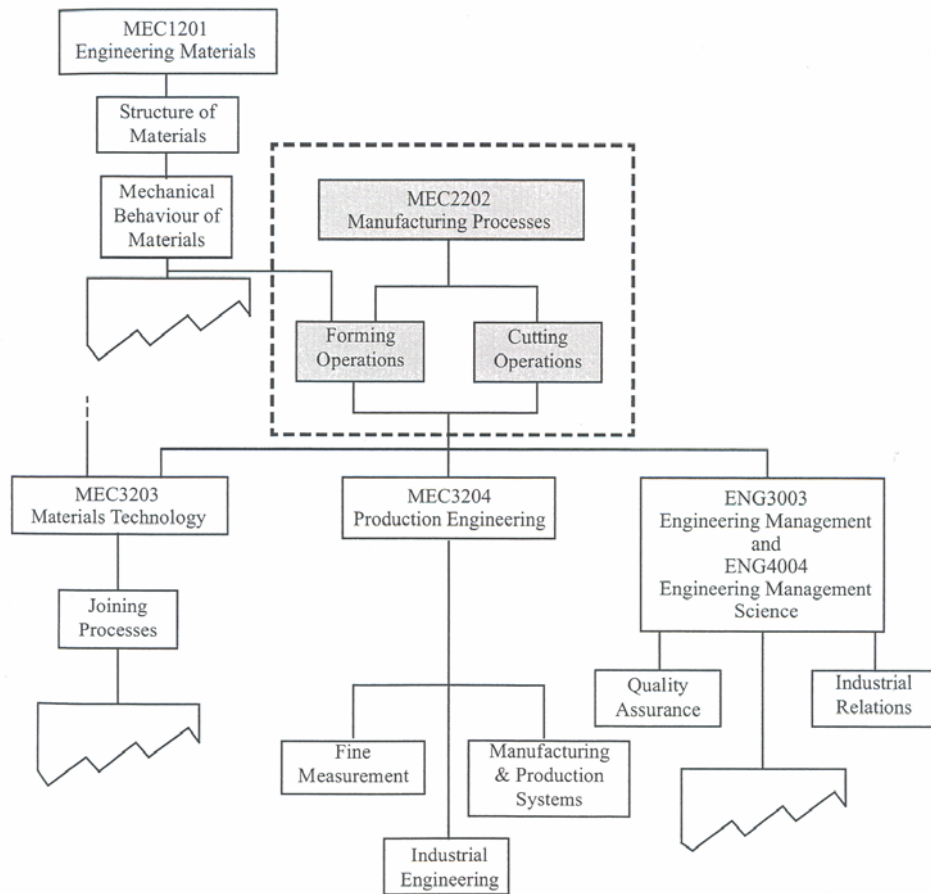
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**Figure 1: Course development process in DeC, USQ.**



**Figure 2: Relationship between MEC2202 Manufacturing Processes and other courses**