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Portfolio Assessment of Laboratory Practicals Integrating Learning Across Modules

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Abstract: Physical Metallurgy, a compulsory module on the part time and full time Materials Engineering degree programme at Sheffield Hallam University has for a number of years utilised a series of separate practical based laboratories in order for students to gain a greater understanding of some key concepts associated with linking microstructure to properties and processing. One of the main issues of these stand-alone practicals was that students were following a menu of tasks, leading to a lack of deeper understanding of key concepts and theories and therefore were unable to link information between each of them. A recent revision of this module has drawn the practical elements into a year-long integrated package of practical work, where students undertake an investigation, developing broader and deeper skills. Additionally the learning strategy utilises the output of another module in manufacturing, using the output of a casting practical linking the two modules with an integrating investigation, eventually leading to summative assessment by portfolio. This paper will detail the development of the new programme of work undertaken by the students and evaluate, using student feedback, and how student learning and achievement has been improved compared to previous methodologies.

Keywords: *Portfolio assessment; integrated learning*

1. INTRODUCTION

Within the Department of Engineering and Mathematics at Sheffield Hallam University, there are a number of courses which cover a wide range of engineering disciplines. One course that runs within this portfolio is the Materials Engineering degree programme. The course is delivered to part time and full time students and is focussed around giving the learner a greater understanding of materials, covering characterisation of materials, materials manipulation and effects on the properties of materials microstructure. Two compulsory level 5 modules (second year degree) which are delivered as part of this course are 'Manufacturing Processes' and 'Physical Metallurgy'.

The Manufacturing Processes is a level 5 module that runs across two semesters and is taught as a series of lectures - incorporating tutorial-type problems - and laboratories. The aim of the module is to give the students a fundamental understanding of different manufacturing processes and the influence of these processes on the material. In broad terms, the first semester covers casting processes while the second semester covers plastic deformation manufacturing processes such as forging, extrusion and rolling. Historically, this differentiation arose as the module was delivered by two different members of staff. However, this resulted in a tendency for students compartmentalize manufacturing as either 'casting' or 'plastic deformation', rather than encouraging them to focus on process selection from a design, materials, or economic perspective. Following a review of the module delivery, changes were initiated; these included: changing the delivery of some of the content from lectures to laboratory sessions, reviewing the content of the laboratory sessions and developing links between the laboratories, both on this module and with other modules on the course. So a series of laboratory practicals have been delivered that reinforce materials delivered in the lecture around a selection of metallic manufacturing techniques, primarily casting and deformation processes. This enables the learner to see the processes in action and in some instances, through the use of macro examination or basic mechanical testing, examine the effects of such processes.

Physical Metallurgy however is primarily concerned with phase constituents within a metal, relating theory of microstructural evolution with visible characterisation and the effect on mechanical properties. The delivery is centred on a combination of lectures, seminars and laboratories. Lectures deliver the theory, with seminars reinforcing practical application of the theory. The laboratories give the learners the opportunity to put the theory into practice in a real world situation, with the associated potential for error to vary actual from predicted structures and/or properties.

Past delivery of the Physical Metallurgy module utilised a laboratory programme that contained distinctly separate practicals, such as 'The effect of carbon content on properties of plain carbon steels' ; 'The heat treatment of steels'; 'Ferrous and non-ferrous metallurgy-Optical examination'; 'True Stress-True Strain'; 'Recrystallisation of Brass'. This allowed the student to see the effects of a particular operation or the ability to determine key information from a particular testing regime. One of the observations made by the delivery team was that although a number of the practicals related to each other, a proportion of the students were unable to make the link between them, which was detrimental to their understanding of the subject. They also saw the laboratory session as just the techniques they were using rather than the learning as a product of using these techniques e.g. using hardness testing to examine the effect of cooling rate on a material or using the same test to examine differences in different alloys.

2. METHOD

Following discussions amongst the module delivery team, it was decided that addressing this issue of lack of integration of different laboratory practicals with theory, overall learning and understanding, would enhance the learning from the module and therefore assist students to make the link between the different practical sessions. Students require their learning to be authentic and this can be simulated to that of an industrial engineering environment [1].

Therefore a laboratory programme was devised that incorporated the learning from the old laboratory sessions. However the new programme was created in such a way to make it essentially two laboratories, each run over one semester (see Table 1). By doing this the students use the same samples for each stage of the work and therefore are fully aware of the history of the sample, therefore making easier links for the student regarding what has been done, the mechanical properties and their associated microstructures.

Table 1. Physical Metallurgy revised laboratory programme

Laboratory Session Title	Tasks	Learning Outcome
Ferrous programme	Heat treatment, tensile testing, hardness testing, sample preparation, optical examination	Understand role of carbon in steel, effects of thermal processing, hardenability of materials and be able to directly relate to microstructure and mechanical properties of a metal
Non-ferrous programme	Heat treatment, tensile testing, hardness testing, sample preparation, optical examination	Understand the effects of work hardening on non-ferrous materials and the effects of recovery, recrystallisation and grain growth on mechanical properties and be able to directly relate back the microstructure.

At the same time, the Manufacturing Processes module was undergoing a revision to the laboratory sessions and discussions were being made around materials that could be used in a casting lab, that was to utilise different casting techniques and would demonstrate differences in a future rolling lab. Members of the course team identified that the samples made during this session and subsequently rolled would feed in very well to the non-ferrous programme of labs on the Physical Metallurgy module, as the same students participate on both modules.

Therefore by using these samples they will again have the history from manufacture, making it easier to link, not only between microstructure and mechanical properties, but also between the manufacturing process routes the materials have been subjected to.

For the Physical Metallurgy module, summative assessment was made by portfolio, with an individual report in semester one and a group presentation in semester two, each based on the work conducted that semester.

A questionnaire survey, using Survey Monkey, composed of 10 questions, Table 2, was conducted at the end of semester two as a means of assessing the student perception of the revised laboratory programme. The survey used a Likert scale of 0 to 5 , with '0' meaning 'don't agree' to '5' being fully agree'.

In addition the university 'Module Survey' was given to the students to review their whole module experience. Those results are also detailed in the next section.

Table 2. Survey questions

Question Number	Question
1	I engaged very well with the module
2	I am satisfied with the module overall
3	I Found the linking together of the Manufacturing Processes module with the Physical Metallurgy module significantly enhanced my understanding of the effects of manufacturing processes on the structure and properties of a material
4	I think the use of a themed lab programme as opposed to individual laboratory practical's worked very well
5	The themed programme very much helped me to link heat treatment, mechanical properties and microstructure
6	The themed lab programme greatly assisted me in my understanding of the module
7	I was very satisfied with the form of assessment for semester 1 (report)
8	I was very satisfied with the form of assessment for semester 2 (presentation)
9	If you were designing the module, what would you do different
10	Any other comments

3. RESULTS AND DISCUSSION

From a total of 34 students on the module, 15 responded to the Survey Monkey questionnaire. See Figure 1 and Tables 3 and 4. For the overall module survey 18 students responded; Tables 5 and 6 show relevant data from this survey.

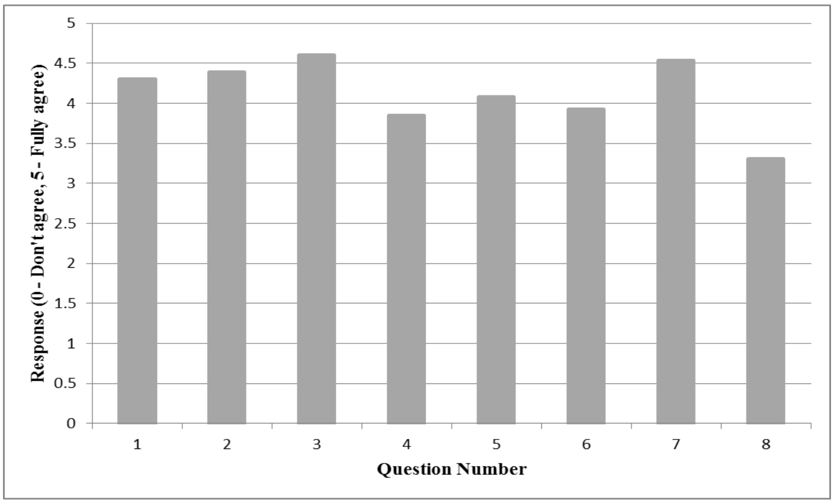


Figure 1. Results from survey

Table 3. Survey responses to question 9

Responses to question 9	"Presentations all the same, would have been nice for each group to focus on something different somehow? Maybe each group use slightly different testing technique or different materials. The different casting techniques didn't show much, if any difference" "Possible get rid of presentation - add it onto the report to make a portfolio" "Replace the presentation with a full portfolio of each lab" "Ensure the lecture material relevant to the laboratory practicals is delivered at the time of the practical session delivery to ensure full comprehension of the laboratory task and understanding of the techniques used and treatments applied" "Group presentations leave some people doing more work than others" "Take out presentations"

Table 4. Survey responses to question 10

Responses to question 10	"Increase the amount of equipment available during the practical session or decrease the number of students to avoid bottle necks during practicals and wasted valuable time queueing for equipment" "Would have liked more time learning about how to identify different microstructural features" "The presentation as a group was particularly hard to coordinate with the group as a part time student"

Table 5. Results from module survey on Module Organisation

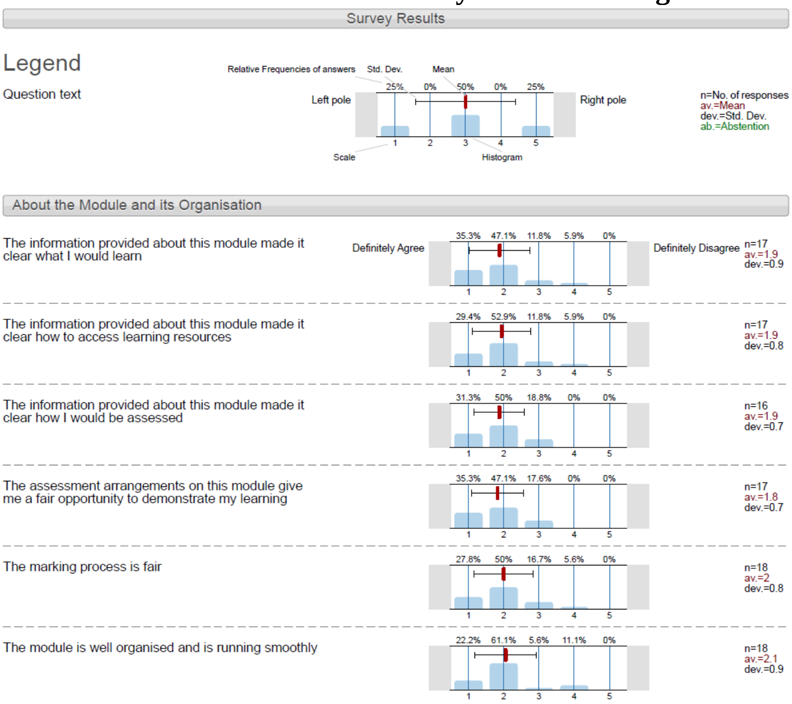
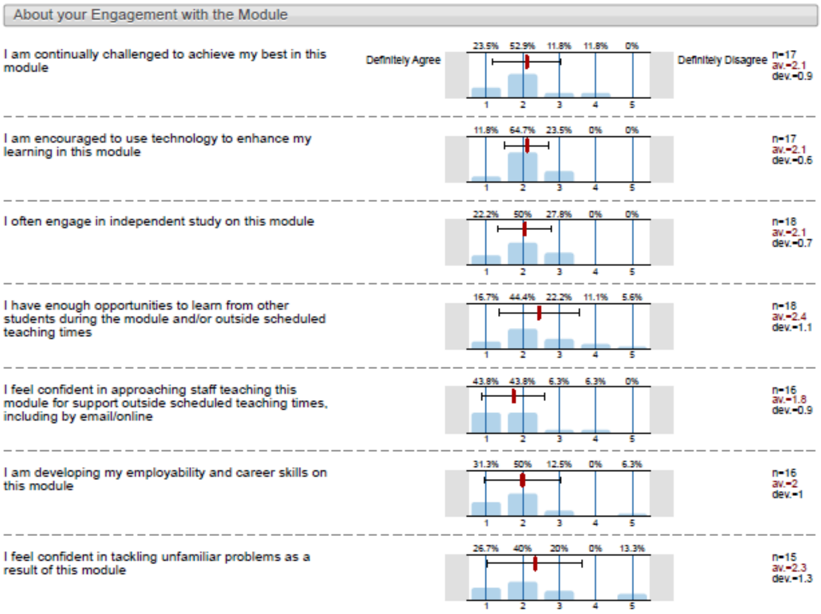


Table 6. Results from module survey on Student Engagement



Student engagement and satisfaction

For both surveys the students rated engagement with the module highly, and were overall very satisfied with the module. The overall satisfaction with the module from the Survey Monkey questionnaire was 4.5 out of 5, and for the module survey this was at about 82%.

Integration of modules

Students reported that linking the two modules together significantly enhanced their understanding of the effects on manufacturing processes on structure and properties of materials, scoring it the highest of all the questions (4.6 out of 5). The themed laboratory programme was well received and helped them to link various theories and practices to enhance their understanding. Harris et al [2] linked modules and assessment utilising a common task across different years of an undergraduate engineering course, which was received well by the students, with the added advantage of cross year mentoring of second year students with first year students.

Assessment

Student feedback from Question 7 showed that the majority of students were satisfied with the semester 1 assessment of their portfolio report rating it 4.5 out of 5. However, students did not like doing the presentation in semester 2, rating it 3.3 out of 5. Comments received as shown in Tables 3 and 4, and from the module questionnaire free comments:

"Presentations all the same, would have been nice for each group to focus on something different somehow? Maybe each group use slightly different testing technique or different materials. The different casting techniques didn't show much, if any difference"

"Possible get rid of presentation - add it onto the report to make a portfolio"

"Replace the presentation with a full portfolio of each lab"

"Group presentations leave some people doing more work than others"

"Take out presentations"

"A presentation (of) group assessments is ridiculous for a part time group! We all see each other 1 day a week whilst in lectures! And live miles apart…..To complete and practice the presentation." (Module Questionnaire)

However, overall, students were generally satisfied with the assessment on the module, with 82% being positive about it, Table 5. These comments identify the main issue for part time students undertaking group work. The lack of physical contact time is regarded as a key issue in them working collaboratively, yet these skills are required in industry when working within a global marketplace, with many companies having multiple sites, and the associated issues of lack of having frequent face to face meetings. Harris et al [3] developed multi-site working of engineering students across Europe. It is interesting to note that the lowest score in the module survey, Table 6, shows that only 60% said they have enough opportunities in the module to learn from other students during the module and/or outside schedules teaching times. Clearly the students need to be briefed on the advantages of group working outside class contact time, and the methods of effective communication that can be employed, such as using Skype, google docs etc. Harris et al pioneered video conferencing across sites many years ago to great effect, but this perhaps still needs the students to be encouraged and supported to do this [3].

Student confidence in tackling unfamiliar problems

Another lower scoring question on the module survey, Table 6, was that only 66% of students felt confident in tackling unfamiliar problems as a result of this module. The point of the themed laboratory programme was to integrate knowledge, and use more of an enquiry based model of learning [4]. It is clear that more work needs to be dome in developing the laboratory programme to increase the student's confidence in this respect.

4. CONCLUSIONS

The laboratory programme has been a success in integrating the two modules, using a laboratory portfolio and group presentations. However, the group presentations, especially for the part time students needs to be reviewed, and either changed, or strengthened in terms of students understanding the need to work in groups, across different physical locations. The activities in the laboratories need to be reviewed to develop the student's expertise in tackling unfamiliar problems, possibly by using more problem based learning types of activities.

5. REFERENCES

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