Effective Plant Tours in Engineering

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Abstract
An effective way of incorporating more experiential learning elements into engineering courses and conducting them as active learning process is by adding site/factory tours to the curriculum. This paper reports research outcomes which help to conduct a successful and active plant tour for engineering students. Acknowledging logistical and managerial aspects of organising such tours, useful techniques are suggested to reduce this load. Pedagogical principles related to factory tours are then reviewed and appropriate activities to maximise the learning of students are proposed.

Introduction
Engineering has been defined as "the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people" [1]. Engineering graduates, therefore, must be familiar with practical applications, real-world problems and their appropriate solutions. Furthermore, to achieve and establish an adaptive curriculum, as defined in “Nine Principles Guiding Teaching and Learning in The University of Melbourne” [2] a sound teaching pedagogy should include practical works from real world associated with lectures/tutorials and projects. In this way engineering courses will provide graduates with skills and knowledge appropriate to their lives after graduation [2]. Therefore, practical works are essential part of any engineering courses to illustrate real professional situations and the complex interactions between all engineering and non-engineering constraints [3].
In recent years, however, rationalising engineering curricula has led to the elimination or reduction of contact hours in practical/laboratory subjects. An indication to this trend can be found in the decreasing number of published articles on the role of practical work in supporting basic teaching. Most of the recently published articles in engineering education journals are on computer-based and virtual teaching. As an example, between January 2000 and December 2001, the International Journal of Engineering Education included 57 papers on computer-based engineering courses, including 12 on "virtual teaching", plus 11 papers on quality assurance and over 32 papers on project-based courses, out of a total of 139 published articles [4]. This alarming trend is also true in the teaching of manufacturing engineering.

In order to solve this paradox, a factory tour was introduced in a third year subject, namely “Manufacturing Studies-2” for undergraduate students in the Department of Mechanical & Manufacturing Engineering. Although the factory tour as a learning experience for the students to overcome the reduction in the practical/laboratory contact hours would seem to be a great idea, making it meaningful however would be more difficult. This paper reports research outcomes which help to plan and conduct an effective and active engineering site/plant tour.

**Pedagogical Principles**

Many lines of inquiry into the science of learning converge on the conclusion that *experiential learning* i.e., learning through experience is fundamental to human development [5,6]. Consequently, rather than considering learning in terms of outcomes, it should be conceptualised as a process, whereby concepts are drawn from, and constantly modified by, experience [7]. In other words, learning is conceived as the process of creating knowledge, based on the transactions between the individual and the environment [5,7]. Similarly, the concepts of *anchored instruction* and *situated learning* are consistent with the fundamental assumptions of experiential learning [8,9,10].

Incorporating practical work in engineering courses is based on the pedagogical principle that for learning to be effective, it must be anchored in a meaningful context for learners [4]. In this way students appreciate how concepts are applied and why
they are important and useful. Further, in such an environment new learning will be more easily integrated into their existing knowledge. In other words, anchored learning environments enable learners to understand how new information is connected to what they already know. Moreover, these processes of accommodating ideas to the external world and assimilating experience into existing knowledge structures are critical driving forces underlying cognitive development [5].

Considering learning as an active process, it is best facilitated by involving the learner in cognitive engagement with the information to be learned [11]. An effective way of incorporating more experiential learning elements into engineering courses and making them an active learning process is by adding site/factory tours to the curriculum. If learning is “about constructing knowledge, not receiving it”; “about thinking and analysing, not accumulating and memorising”; “about understanding and applying, not repeating back”; and “about being active, not passive” [12] then students should be challenging themselves on site/factory tours. However, adding such tours to a course requires careful planing, preparation and management to ensure success.

Managerial Aspects of a Factory Tour
The main objective of any site/factory tour is to conduct a well-managed and motivational experience that also serves as an effective curricular learning tool. In order to achieve this goal, first managerial details of the visit (e.g. finding a suitable site/factory, booking a tour, transportation, getting safely to and from the site on the appointed date and time) need to be carefully considered. These logistic issues require a lot of time and energy from the academic staffs in charge of the subject. However, there are some techniques which can be used to reduce the managerial load on the subject-coordinators.

Getting students to invest in what they will be doing is very important. The more ownership students have in an event, the more they will engage in it [13]. Therefore, in planning a factory tour for 3rd year Mechanical & Manufacturing students, they were asked to arrange individual tours that interested them. Giving students a chance in determining a factory tour location allows and encourages them to take
responsibility for their own learning. The benefit of having individual tours as opposed to large group visits is obvious from logistical point of view. Moreover, group tours with more than 80 students cannot be carried out in small factories, where much more technical and non-technical detail can be shared with students in contrast to big plants. In addition, the amount of the time a guide person is dedicating for each visitor is much limited in a large group. Furthermore, involving students directly in all stages of the tour will give them a chance to learn skills that might not be covered formally in the course [14]. Although almost all managerial issues in this case were left to students, it is necessary to let them know what will be expected before, during and after the event.

In order to run a successful factory tour; either individual or group tours; students should be connected with curriculum content during the event. To this end, it is necessary to plan interesting activities before, during, and after the tour itself to encourage students to hypothesise, compare, analyse, synthesise, and reflect on their experience. The range of these activities can be extended from collaborative or individual learning to problem solving as well as other applications of content and skills. The main objective of all activity ideas listed in this paper is to help students to focus their learning, consider new ideas in the light of existing schema, highlight for others new knowledge and skills learned from the tour, and even possibly confront discrepancies in their learning [13]. It is important to plan these activities in such a way that they help to create an event which is challenging students’ evolving understanding of content.

**Pre-Tour Activities**

1. Students need to actively engage with new information which will come in handy during the factory tour in order to understand and learn it well. To fulfil this, all factory tours should be explicitly related to course materials. Developing and assigning explicit learning outcomes for the tour is a must.

2. Prior to any tour, the tour’s significance should be emphasised. Academic staff should clearly outline what the students are expected to learn and how the destination and its activities relate to student interests.
3. Giving a general picture of non-technical information that students may find out during a tour is another way of motivating students. For example, emphasizing on the following points is beneficial.
   - “a factory tour is an excellent introduction to what engineers really do”
   - “the tour can be a good starting point for networking”
   - “nearly any company can hire anyone at anytime”
4. It is a good idea to brainstorm pre-tour with students about the questions that they would like to be answered during the course of the tour. Creating a template for information hunting for students to complete while on the tour can be a product of such brainstorming sessions.

5. Another way to build readiness and excitement for content-related learning is to help the students create frameworks for the new understandings that the tour will bring. In designing such a framework the following points should be considered:
   - Students should actively seek out information that makes them think
   - Compare it to what they already know
   - Internalise new information
   - Question what seems problematic

6. Having a clear idea of expectations and assessment methods of the tour is necessary for students. Therefore, framing students’ post-tour projects or presentations/reports should be done at this stage.

7. Conducting literature-based activities before a tour is a very useful activity [15]. Orion and Hofstein [16] found that field trip learning was increased when students had preparatory lessons prior to the trip. In this case asking students to check web-pages of the company before starting the tour is another way of preparing students for much fruitful event.

8. Students should be given basic guidelines on safety and managerial issues. Asking them to wear appropriate clothing and footwear is essential. They need also check specific safety rules, materials to bring and not to bring with the tour guides before commencing their tour. Students should be asked to confirm their appointments two days in advance and a “thank you” letter should be sent to their tour guide after the event.
Post-Tour Activities

1. Post-tour activities can be used as a tool to assess student learning from the factory tour. Based on the circumstances two types of assessments can be conducted: informal, formative assessments of continued instruction or formal, summative assessments of learning [17]. In either way students will be included in the evaluation of the factory tour itself. It is very important to have students review their curricular content learning with both their lecturers and their peers.

2. Students need to discuss what they have learned and discovered during the factory tour. In doing so, the students repackage and synthesize important content-related learning. Interacting and sharing this information is a part of the learning experience. It helps students reconstruct, reinforce, and delve more deeply into understanding while expanding their own horizons [13].

3. After students have processed the new information highlighted by the factory tour, this will be a good opportunity for lecturers to find ways to link the content and skills of the factory tour experience to future curricular units.

Closing

The goal of any factory tours is conducting a well-managed and motivational experience that also serves as an effective curricular learning tool. All of the activities suggested in this paper can be considered as tools to assist in achieving this goal. The final aim is to facilitate active cognitive engagement of students in learning by running such events. It is evident that by providing such an environment, a significant increase will be achieved in student learning.

References


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