Implementation of Experiential Learning in Virtual Mode in an Undergraduate Program of Engineering Technology

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1. Abstract:

This case study details the design, development and implementation of experiential learning in virtual mode for two courses namely, Mechanical Technology and Manufacturing Processes for a large student set (over 500) who are employed in various Engineering Industries. The students are qualified diploma holders in Engineering and are enrolled for an undergraduate program of an Indian technology and science university. The case details the (1) design of the experiential learning to achieve the students learning outcomes of the courses (2) development of the virtual exercises (3) implementation across student locations and (4) students' learning and experience assessed through a graded assignment and their feedback. A three step pedagogical approach was taken namely, (i) active observation (ii) assisted attempt and (iii) experimentation. The study reveals that the experiential learning could be achieved in virtual mode in core engineering & technology courses and the students could be engaged actively in the learning process.

2. Purpose of Research:

Technology is 'application' of scientific knowledge for practical purposes. Application skill is gained through experience. Thus learning technology essentially means experiential learning. The conventional experiential learning is gained through a physical infrastructure such as lab or industry. This research experimented the possibility of offering experiential learning through a virtual mode for two core technology courses using computational tools that replicate the real processes.

Although this research scope is limited to two core technology courses, the experiential learning process can be replicated in many similar instances. It is expected that this approach can be applied in general for gaining experiential learning on virtual mode, which can expand the scope of courses offered online.

3. Methodology:

The research is based on the study conducted over two core technology courses over a semester period of 4 months in an under graduate program in Engineering

Technology. The study used (1) course outcomes detailed in their respective handouts (2) sophisticated computational tools (3) learning artefacts (4) assessment problems (5) student lab work (6) grading sheets and (6) student feedback on the learning and experience.

4. Description:

Technology is defined as ‘the discipline dealing with the art or science of applying scientific knowledge to practical problems’. Such an application-orientation emerges out of ‘experiential knowledge’. Experiential knowledge are essentially ‘know-hows’ that are tacit in nature. People who have technical tacit knowledge are considered unconsciously skilled[1]. Reportedly, over 70% of the organization knowledge are tacit in nature. Contrasting this, an explicit knowledge is something that can be codified, captured and stored in databases. The information we obtain over the World Wide Web is such a knowledge, they are useful but cannot be applied without the fundamental tacit knowledge. The classic example quoted in tacit knowledge research is ‘cycling’, which requires practice and not the science behind bicycling. This distinction has implications for teaching-learning of technology, where the objective is solving societal and industrial problems using technology. Pedagogy is the key in transferring tacit skill that objectivizes technological problem solving.

Transferring tacit knowledge

Nonaka[2] in his popular paper on knowledge creating company proposes a knowledge transfer model. He lists Observing, Imitating and Sharing experiences as the processes of tacit knowledge transfer. Combining cognitive learning concepts with the Nonaka model we propose a four step process for tacit knowledge maturity.

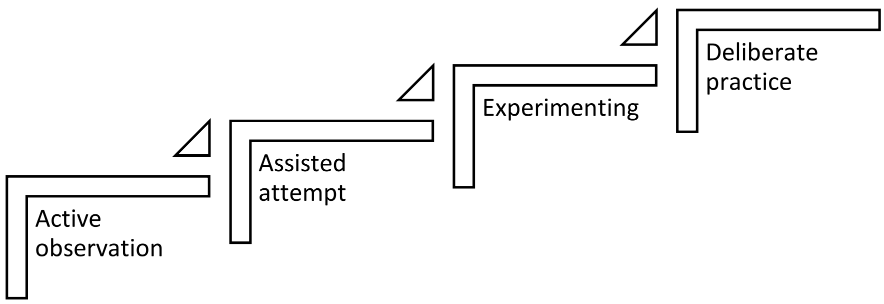

Fig 1. Four step process for the transfer of experiential-knowledge

Active observation, is the process of watching the performance of an expert attentively. In learning bicycling a novice carefully observes the cycling by an expert. The way the expert holds the handlebar, his posture, his pedaling action, usage of breaks etc., are carefully observed by the learner as the first step.

Assisted attempt, is the next step wherein the learner makes his early attempts to perform the task under the careful assistance of an expert. The learner mimics the expert in all ways. However, due to lack of dexterity, the learner makes several mistakes, which are promptly corrected by the expert. In the case of bicycling such mistakes may lead to minor accidents leading to injury and damage to the equipment.

Experimenting, is the stage at which, the learner makes an independent attempt. The rigor and complexity of the experiment depend upon the experience gained through the 'assisted attempt'. Mistakes are not absent in this stage but are reduced. However, this is the early stage at which, a learner can be assessed of his learning.

Deliberate practice, as proposed by Anders Ericsson and Robert Pool[3], is a focused practice of the task with a specific goal under the guidance of an expert who provides feedback on nuances, which create the right mental representation for the learner. This is how a mere bicyclist transforms into a champion. This is different from the repeated independent practice by an individual, which is wrought with the danger of wrong mental representation that is hard to change.

Adopting the model in technology education

Organizations use various approaches such as communities of practice (CoP), shadow-following, case-based reasoning, organization-storytelling, analogies etc., which are rooted in the above model. They are useful but are limited by scope and context.

Learning through failed attempts and experiments can be costly in an organization set up. Falling from a bicycle can be acceptable but not crashing an airplane in an attempt to land for practice.

The advances in computing and virtualization have made it possible to deploy the *assisted practice* and *experimentation* through a virtual lab set up, where the failed attempts are translated into active learning. The instantaneous feedback acts as a calibration of mental representation of the learners.

The paper deals with an experiment conducted in technology education using such a virtual laboratory adopting the four step process detailed above.

The premises

The model is tested in one of the first degree program in Engineering Technology offered by Birla Institute of Technology & Science, Pilani for working professionals through their Work Integrated Learning Program Division (WILPD). Two core technology courses were selected for the experiment namely, Manufacturing Processes (S1-16 ET ZC235) and Mechanical Technology (S1-16 ENGG ZC243). The number of students registered for these courses were 337 and 152 respectively. Out of these registered students, 262 and 132 students participated in the experiment by attending the lab sessions and completing the graded assignment administered. The students were diploma holders working in various engineering organizations with a work experience of minimum two years. All the students were in their first semester of second year of the program (3^{rd} semester). They had already completed their foundation courses in mathematics during the first year of the program. Four lab experiments were administered to the students as a part of this experiment two for each course. They were designed and developed by a team of university faculties exclusively for the courses. The assignments were deterministic in terms of outcomes avoid subjective answering and judgments. Each experiment were with 5-10% weight. In order to avoid any copying the assignment questions were differentiated by varying the parametric details such as material, fluid, pressure etc.

The software simulation tools were hosted in remote desktops and the access control was provided to the students on a scheduled basis. Students either practiced or experimented from multiple locations over a period four weeks in multiple timeslots.

Labs were managed by trained technicians who were adept in the simulation tools and possessed expertise in subject matter. They were higher degree holders in technology.

Lab administration

Observation: Lab for each course was comprised of two hours of online tutorial offered by lab technicians. The online tutorial were supported with additional reading materials and the students were advised to audit them spending about 12 hours.

Assisted practice: Students accessed the simulation tools live in the remote desktop through an access control system and practiced a set of defined exercises. The lab technicians supported the students both technically and administratively during their practice sessions. Students' doubts were clarified through instant messaging tools or over telephone. The tracking mechanism ensured a minimum of 8 hours of practice assisted by the technicians.

Experiment: Students after successfully completing their practice were offered an assignment question picked randomly from a set of 5 questions and allowed to perform their experiment. Such attempts were proctored by the lab technicians. The support was limited to administrative issues and no technical support was provided to the students. Students spent 60 to 90 minutes in the experiments. A very few students spent 120 minutes to solve the experiment problem. The submitted reports were assessed by the faculty team that developed the exercises and graded.

Deliberate practice: This is an extended practice using the simulation tool, which is scheduled as a part of the dissertation project during the concluding semester of the program. This is not included in the scope of this experiment.

5. Test Criteria

It was expected that the learning process of *observation and assisted attempt* would facilitate gaining *experiential problem solving skill* even through a virtual lab model. The measured ability of a student's *problem solving skill* could serve as an indicator of this knowledge acquisition. A well-defined application-oriented problem solved by the students post their *observation and assisted* attempt would verify this premise.

The student engagement could serve as a proxy measure for the learning-space created by the online lab. This is considered to be an enabler particularly in virtual learning environment.

6. Results

S1-16 ENGG ZC243

1. An exercise on a heat engine cycle to determine the power, thermal efficiency, mass flow rate and quality of output for a given set of input parameters.
2. An exercise on a refrigeration cycle to find the compressor power, volume of cooling water and COP for a given set of input parameters.

Total number of students registered for the course	152
Number of students participated in the lab	132
Number of students successfully completed the lab with a perfect score	132
Number of students who could not succeed in solving the lab problem	-
Percentage of success	100%

S1-16 EC ZC235

1. An exercise to find the defect of a casting and to select the appropriate process parameters to eliminate the defect.
2. Selecting the appropriate process parameters to forge certain parts successfully.

Total number of students registered for the course	337
Number of students participated in the lab	262
Number of students successfully completed the lab with a perfect score	200
Number of students successfully completed the lab but less than a perfect score	62
Number of students who could not succeed in solving the lab problem	-
Percentage of success	100%

Student feedback

S1-16 ENGG ZC243

Out of 132 students who underwent the process of active *observation, assisted attempt and experiment*, 62 students provided feedback, which was collected through an anonymous survey.

Measure	Below average	Average	Above average
Technical learning	-	1.6%	98.4%
Technical support	-	-	100%
Overall rating	-	-	100%

S1-16 EC ZC235

Out of 262 students who underwent the process of active *observation, assisted attempt and experiment*, 168 students provided feedback, which was collected through an anonymous survey.

Measure	Below average	Average	Above average
Technical learning	4.8%	3.6%	91.6%
Technical support	4.8%	1.2%	94.0%
Overall rating	4.8%	3.6%	91.6%

7. Conclusion

The study reveals that the experiential learning could be achieved in virtual mode in core engineering & technology courses and the students could be engaged actively in the learning process. However, the impact of this learning in a real life setup may be tested through an extended experiment.

8. Implications:

In this study we identify key steps that need to be considered for a successful implementation of experiential learning in core technology courses over virtual mode in the context of an Indian technology and science university.

9. References

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