Applying an Inductive Method to a New, Multidiciplinary, Management of Innovation & Technology Course: Evidence from the University of Nicosia

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Abstract—Managing **Technological innovation is one of the most important aspects of business for management, business, management information systems (MIS), engineering and science students to learn. Academics and practitioners, who teach topics related to technology innovation to multidisciplinary classes, usually they do so deductively, that is the lecturer introduces the general principles and continues with applications of those principles. A common observation is that University students do not see any motivation knowing that someday they will need those knowledge and skills. A *Student-centered teaching method* on the other hand shifts the focus of activity from the lecturer to student including *inductive teaching* and learning.**

The new, elective "MGT370- Management of Innovation and Technology" course was to engage students from different specializations in a collaborative environment in which students have access to assignments based on real-world case studies and problems. After a group open-discussion a preliminary analysis of students' perceptions towards technology innovation content knowledge faced a significant contradiction.

This paper presents a review of the unique features of the main inductive methods, describes the new elective Management of Innovation and Technology course, presents assessment outcomes, reports the learning outcomes after the employment of inductive learning strategies in the course and gives recommendations on how assessments are being used to deploy, manage and improve the course.

Keywords-problem-based learning; technology innovations; student-centered method; inductive teaching and learning method;

I. INTRODUCTION

Academics and practitioners who teach specializations such as MIS, and Science traditionally do so deductively. Students are introduced to theory and mathematical models and then are given exercises from the textbook and possibly some real-world cases/applications to analyze. A general observation is that teaching technology innovations to multidisciplinary classes generates questions on whether any real world cases could be explained; can any practical problems be solved; does all this knowledge meet the interests of a multidisciplinary class; and finally is it really a motivation telling students that they will need certain knowledge and skills someday [1]. Is it really motivating to know that what they are learning will be useful for their curriculum and further for their careers? Based on references [2] and [3] the most common reason for students to leave sciences is the lack of connecting the course material to the real world.

A student-centered approach where the student is responsible for his/her own learning by building his/her own version of reality is an alternative approach to learning. Specifically a student-centered approach includes inductive teaching and learning where students are primarily presented to a precise challenge, like a real-world case study to analyze, seek a solution to a complex illustrated open-ended real-world problem or interpretation of experimental data. While dealing with these challenges, students realize that they lack skills, knowledge, facts and conceptual understanding and they request the help of the lecturer, who plays the role of the facilitator. Based on references [4], [5] and [6] it is demonstrated that inductive methods encourage students to adopt a deep approach to learning that lead to further intellectual development. Inductive teaching and learning incorporates the following learning methods: inquiry, problem-based, project-based and discovery as wel as case-based teaching and just-in-time teaching. Prince and Felder [1], one of the few who have examined these methods as a group, have reviewed several of the most commonly used inductive teaching methods defining each method, highlighting commonalities and specific differences, and reviewing research on of their effectiveness for and science education.. This paper presents a review of the unique features of the main inductive methods, describes the practical applications of: inquiry learning, problem-based learning, and case-based teaching in the new elective course MGT-370 Management of Innovation and Technology and discusses practical issues of implementation specifically in meeting the needs of a multidisciplinary class. Finally it attempts to

evaluate the effectiveness of the various activities. Recommendations are given to academics and practitioners for designing their curriculum based on a student-centered approach using inductive methods for: the development of critical thinking and creative problem-solving skills, a deeper understanding for formation of positive attitudes and confidence in knowledge or skills toward the course [1].

II. LITERATURE REVIEW

A. Student Centered Teaching Methods

During the last few decades, education literature presents a broad variety of student-centered teaching methods and presents evidence that a proper implementation of a student-centered method could lead to: rise of motivation towards learning with more positive attitudes toward the subject, greater retention of knowledge and deeper understanding [8,9,10,11].

Student-centered teaching methods shift the focus of activity from the teacher to the learners. These methods include active learning, competitive learning and inductive teaching and learning placing the emphasis on learning instead of teaching. Academics and practitioners are continuously seeking ways to enhance, enrich their classes as well as motivate their students. More specifically, in higher education, for an elective Technology course, taken by business, management, management information systems (MIS), and science students, one approach is to be such targeting to an assessed short-term mastery, a depth of course material understanding, critical thinking acquisition, creative problem-solving skills, formation of positive attitudes toward the subject, and level of confidence in knowledge or skills.

B. Inductive Methods

Inductive teaching and learning include a range of instructional methods: inquiry-based learning, case-based instruction, problem-based learning, project-based learning, discovery learning, and just-in-time teaching. All these methods are all student-centered; are initially presenting to students challenges (questions or problems) and continue with studying the course material in the context of addressing these challenges. In class students are actively involved in discussing questions and solving problems (*active learning*), while in and out of class the work is done in groups (*collaborative learning*). [1] have summarized in a table the features of common inductive teaching methods Table I.

TABLE I. Source Journal of Education 95(2), p. 124

Method► / **Feature▼**	**Inquiry**	**Problem-based**	**Project-based**	**Case-based**	**Discovery**	**JITI**
Questions or problems provide context for learning	1	2	2	2	2	2
Complex, ill-structured, open-ended real-world problems provide context for learning	4	1	3	2	4	4
Major projects provide context for learning	4	4	1	3	4	4
Case studies provide context for learning	4	4	4	1	4	4
Students discover course content for themselves	2	2	2	3	1	2
Students complete & submit conceptual exercises electronically; instructor adjusts lessons according to their responses	4	4	4	4	4	1
Primarily self-directed learning	4	3	3	3	2	4
Active learning	2	2	2	2	2	2
Collaborative/cooperative (team-based) learning	4	3	3	4	4	4
1 – by definition, 2 – always, 3 – usually, 4 – possibly						

The differences among the above mentioned inductive methods are obvious. In the literature each method has its own research base, history, guidebooks, supporters, and critics, and is not clear what the methods are and how they are interrelated [1]. Lohman [12] claims that similarities of case-based and problem-based learning are obvious; however, in problem-based learning students are confronted with poorly structured problems driving to acquisition of new content knowledge while in case-based learning students analyze hypothetical situations, well structured, detail context-rich, involving solutions to problems and/or decision making. Katsikitis *et al.* [13] comparing case studies to problem-based learning found no significant difference between the two methods as far as performance or knowledge acquisition. The following paragraphs summarize definitions and applications of inquiry, problem-based and case-study learning methods that have been implemented in this paper.

Inquiry Learning- The focus of inquiry learning is on answering questions, solving problems, or explaining a set of observations [14]. Lee [15] in his work states that students should learn to "formulate good questions, identify and collect appropriate evidence, present results systematically, analyze and interpret results, formulate conclusions, and evaluate the worth and importance of those conclusions" only after an effective implementation of the method. Similar outcomes could derive after an effective implementation of a problem-based learning as well as certain forms of case-based instruction.

In this paper *inquiry learning* is implemented *as an instruction tool* using questions and problems providing contexts for learning strategies in ways of using strategic management of innovation to enhance firms performance.

Problem-based Learning – This approach to teaching offers students opportunities to learn via contextualized problem sets and situations. Through the group work and independent investigation, they achieve higher levels of comprehension, develop more learning, knowledge-forming skills and social skills. Lessons may be designed using different scenarios such as: a) entire class discussion b) group of students reporting their progress on earlier learning issues and listing their present learning issues and future plans of work, (c) short

lectures on group work, aiming to keep class up-to-date on general issues, clarify common difficulties, as well as suggest additional learning issues [16].

According to meta-analysis of the effectiveness of problem-based learning done by a group of scientists [19], 43 empirical studies were identified having effects on problem-based learning, knowledge acquisition and development of problem-solving skills,

This paper discusses the implementation of a problem-based learning using problems that vary significantly in scope, from single-topic single-discipline problems to multidisciplinary problems that meet the needs of a multidisciplinary class.

Case-Based Learning - cases teach students about realistic decision-making situations involving one or more challenges: diagnosing technical problems and formulating solution strategies, making business management decisions taking into account technical, economic, and possibly social and psychological considerations, and confronting ethical dilemmas [1]. The cases should be real-life —situations based on professional practice coming out of magazines, newspapers or interviews from those involved in the case.

The idea of using real-world case studies, on technology innovations, in this course was based on Lundeberg, Levin and Harrington, [1] work stating that with real world case-studies students will be able to:

- analyze complex real-world cases,
- acquire theoretical and practical understanding of the subject
- become aware of the kinds of situations possibly facing as professionals in the future,
- develop critical reasoning skills,
- explore their existing preconceptions, beliefs, and patterns of thinking, and
- make necessary modifications in those prejudices, beliefs, and patterns to accommodate the realities of the cases.

C. Management of Innovation and Technology Course

MGT-370 is an undergraduate elective course under the management specialization. The main objectives of the course are

- Introduce of the important role of technology innovation in the Management strategy
- Understand the theoretical knowledge underlying the technological change and the ways firms come up with innovations
- Provide an overview of the strategies that firms use to benefit from innovation
- Understand the importance and role of formulating technology strategy**;**
- Design, develop and integrate a strategic management of innovation and technology

III. RESEARCH METHODOLOGY

To address the research objectives of the study a case study design was employed [7]. A case study based on Merriam;s [17] work that research focuses on discovery, insight and understanding from the perspectives of those being studied offers the greatest promise of making significant contributions to the knowledge base and practice of education.

With the qualitative case study research the researcher has approached the problem of a newly introduced technology innovation course to a multidisciplinary class, a problem of practice from a holistic perspective in order to gain an in-depth understanding of the situation and its meaning for higher education lecturers. The attention was focused in the teaching/learning processes rather than learning outcomes, in the general course context rather than some variable and in the process of discovery rather than in conformation.

The research method was designed to answer the question, how do students from different specializations in an inductive learning environment perform, collaborate, exchange ideas and acquire the subject.

The new course, MGT 370, management of Innovation and Technology was offered two times per week, sessions of 75 minutes each, to a multidisciplinary class of 10 undergraduate students. The curriculum was designed based on a student-centered approach including an inductive teaching and learning method.

To measure students' perceptions towards subject matter learning at the beginning of the course a pre-test has been completed to asses their conceptual knowledge of the principles of applying strategic management of innovation in a firm. Further based on the objectives of the course students worked, individually and in groups on question answering, situation exploration, realistic decision-making situations, contextualized problem sets and situations.

The classroom activities and Outcomes questionnaires provided data on student attitudes toward collaborative learning, problem-solving activities, and interaction with the lecturer and peers.

IV. DATA ANALYSIS

Based on the sample of the study the analysis of the results was made based on group work skills, communication and problem solving skills and content learning. The lecturer has moderated students work in class and has documented the pre-test results as well as their assessment results. see Table. 2

Inquiry Learning*:*

Students were given a question or problem based on real world technology evolutions as well as technology adoption sand diffusion or they have suggested a technological innovation of their preference so as to formulate good questions, search and gather suitable evidence, present results systematically, analyze and interpret results, formulate conclusions.

- *group work skills* - Science students reported that for such kind of assessments they prefer to work individually because they seem to have different preferences and knowledge towards technology innovations; they could formulate and structure in a different why their questions as well as search, gather, analyze and especially formulate conclusions.
- *communication* - Business and management students proved to be more communicative towards science

students and were suggesting real-life problems from businesses.

- *problem solving skills* – all students were thinking creatively and critically about ways to solve the given problem. Difference in backgrounds helped students to approach different related solutions fact that enabled them to analyze and interpret and present the results systematically.
- *content learning* – Content learning for all students was significantly satisfactory based on the discussion that derived at the end of the class.

Problem-based learning:

Contextualized, complex, open-ended, authentic problem sets on sources of Innovation and selection of innovation projects were presented to students individually and/or in groups for investigation. A class discussion followed as well as a group progress report on earlier/present learning issues and future plans.

- *group work skills* – students in some problems were asked to work individually and then join their peers into groups (coming from various disciplines) to exchange their findings, come up with a common solution and report it. It was interesting to note that the combination of independent investigation and group reporting led students to report solutions based on a combination of technical, business, management way of thinking and the reports were quite satisfactory having a professional view.
- *problem-solving skills* - based on the final group report, the observation was that students have reached a level of analytic comprehension through problem-based work.
- *communication* – During discussions for the development of the group reports students seemed to have shown resistance in sharing their investigation results. This basically derived from differences in the way they have approached the given problem and came up with solutions..
- *content learning* – the solution of problems based on the aims and objectives of the course required knowledge and skills. The complexity of the problems intrigued students, forcing them to go deeper into research to find and integrate material from various related sources so as to come up to a solution. This way students gained a better understanding of the courses content, developed problem-solving professional skills and have broadened their subject knowledge.

Case-based learning:

Real-world cases on technological innovations from the Harvard School of Business database were given to students targeting to expose them to the analysis of complex real-world cases, situations that they may possibly face as professionals in the future. Exploring, analyzing and discussing case real life situations students can better acquire theoretical and practical understanding of the subject and develop critical reasoning skills. Through initially individual work that was followed by group discussions and then group presentations, students will explore their existing ideas, beliefs, and thinking models so as to be flexible and make alternations their existing ideas, beliefs, and thinking models towards the realities of the cases

- *group work skills* –Students have analyzed the given case studies individually and then joined groups, again coming from different disciplines cases, so as to prepare for a group presentation. A noticeable exploration of beliefs, idea different way of thinking and analyzing the given situation led some students to disagreements. The lecturer who was working as a facilitator had to interfere and moderate the discussions clarifying some issues on the realities of the case targeting the modification of students' ideas, beliefs and thinking models so as to arrive to a common solution for presentation.
- *Problem solving skills* - Individual work on cases though has developed students' abilities in identifying relevant issues and improved their reasoning and problem-solving skills. Exploring, analyzing and discussing real life situations students have developed critical reasoning skills in finding creative solutions. It is interesting to note that if compare case studies to problem-based learning there were no major differences between the two methods related to performance or content learning.
- *Communication* - communication among students during the second stage of the case-based lesson plan was not satisfactory enough due to differences in educational background ideas, beliefs and thinking models. Some students have shown dissatisfaction in having to collaborate in their case analysis results with peers having different specializations.
- *content learning* – by exploring real-life cases, discussions of the results with peers and group presentations the performance of the students indicated gains in theoretical and practical understanding of the subject as well as case studies students' ability to recognize multiple perspectives was enhanced. Using cases developed students' ability to identify relevant to the content issues and exposed them to experiences and problem based situations.

V. CONCLUSION

Transformations from teacher-centered to student centered learning involves fundamental changes for both students and lecturers.

The inductive method used for this empirical study incorporated Inquiry learning - observations, problem-based learning – contextual complex problem solving, and case-based teaching – real-life case analysis.

Inquiry learning proved to be the approach that required a lot of effort from the lecturer in designing the context, based on questions and problems.

Problem-based learning incorporated complex, open-ended, authentic problems whose solution requires knowledge and skills specified in the courses aims and objectives. A variety of interpersonal problems had been raised during this method due to multidisciplinary educational background in group-work.. The lecturer must interfere as a facilitator to help student groups become effective teams targeting the development of students' professional skills such as problem-solving, and self-directed or lifelong learning.

The use of cases proved to be effective for the current elective undergraduate course with a multidisciplinary audience since learning aims and objectives incorporate decision-making in complex authentic situations. The selection of cases must address the learning aims and objectives with a wide variety of scenarios, had been raised such as identifying technical problems, developing solution strategies and making business management decisions.

The adoption of inductive methods can not reassure better learning and satisfaction for both lecturer and student. Any new teaching method should be very well planned, organized and implemented to meet the needs of the curriculum and students.

Students exposed to this methods that require more individual work full responsibility of their actions and minimum guidance must feel the lecturer as the facilitator who at the right time will offer them appropriate amount of guidance and support.

Lecturers deciding to implement inductive methods in their curriculum, they must search for cases, problems, complex situations that are based on real life scenarios that will offer students opportunities to exchange ideas, believes, knowledge, experiences and come up with professional solutions.

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