Mini-Case Study Pedagogy: Experience from a Technical Course in an Information Systems Program

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Abstract— **This Innovate Practice full paper, describes our experience in using the mini-case pedagogy to design and deliver a technical course, "Enterprise Integration" which is a year two course in the Information Systems undergraduate program. Case method is one approach that has been widely adopted in teaching many professions including law, medicine and business. The general practice is to ask students to read the case, usually four to eight pages long, prior to the session, and then spend the whole session discussing the case. However, for technology courses, the students are required to learn concepts and apply them using hands-on software tools through lab sessions. Hence, rather than use long cases, that cover the entire session, we need to use mini-cases that are usually one to two pages long. This pedagogy approach allows the class session to be designed with tight integration across the concept presentation lecture, mini-case analysis and hands-on lab session. We share the pedagogy implementation details and challenges, and discuss our findings and lessons learnt in designing and implementing the mini-case pedagogy. Thus providing one pathway for Information Systems and Computer Science professors to, implement the mini-case pedagogy in "technology heavy" courses.**

Keywords— Mini-Case, Case Method, Information Systems, Pedagogy, Enterprise Integration, Technology Courses

I. INTRODUCTION

Faculty teaching technical courses within a computing or information systems program face the difficult challenge of how to prepare students for the real world of computing practice. It is essential to teach concepts and principles but at the same time one has to somehow translate this directly into real-world activity, for example, in software engineering discipline, how to design, develop and maintain software solutions. One approach that is widely adopted is the use of case method. Case method has been successfully applied in teaching many professions including law, medicine and business. From a broader perspective, in early school education, researchers have also argued for fitting context, similar to a "case", into learning, for example when learning mathematics [19]. Though there is great pedagogical value in case method, traditionally, computing programs have not fully leveraged this method for teaching due to the limited availability of technical cases. More recently, case studies and their relevance to science and engineering disciplines has been steadily growing [15] and [18].

The case method uses two elements namely the case, and a set of activities related to that case. The case is a rich narrative that provides detailed information about a situation in which an individual or group must make a decision or solve a problem. A standard case is usually lengthy, around four to eight pages and requires a lot time to read and prepare. The usual practice is hence, to ask students to read the case prior to the class and then the entire class session is spent on discussing the case. However, within the information system program at our university, and elsewhere, the students are required to learn concepts and also apply them using hands-on software tools through lab sessions. Hence, rather than the use of long cases, we propose the use of mini-cases which are usually one to two pages long.

The mini-case pedagogy approach allows the class session to be designed with tight integration across the concept presentation lecture, mini-case analysis and hands-on lab session. This approach has a number of benefits. Firstly, the mini-case provides a real-world relevance to the concept material being studied. Secondly, the mini-case allows students to apply the concept learnt in the lecture. Lastly, the hands-on lab session built on the mini-case scenario enables the students to apply the concept using software tools.

In a competency driven program, the students are required to acquire skills applicable to real world. Our innovative integrated mini-case pedagogy supports the acquisition of real world skills in technology intensive courses in an effective and efficient manner. In this paper, we first describe the mini-case design model followed by the mini-case delivery model, and finally we share our experience and findings in using the mini-case methodology in the design and delivery of a technical course, "Enterprise Integration" which is a year two course in the Information Systems undergraduate program.

The rest of this paper is structured as follows: In Section II, we review other related work in two areas namely case method pedagogy, and use of case method in engineering education. In Section III, we present the mini-case design framework and the delivery model. In Section IV we provide a detailed description of how the mini-case pedagogy is applied in a year two undergraduate technical course within an Information Systems program. In Section V, we present the evaluation of the mini-case pedagogy based on survey conducted with the students, and from the reflections of

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instructors teaching the course. Section VI concludes with a summary and areas for future work.

II. Related Work

The case method uses two components, namely the case, and a set of activities related to that case [5]. The case is a rich narrative that provides detailed information about a situation in which an individual or group must make a decision or solve a problem. Cases take many forms, and there is a variety of ways to write them. Usually it comprises the following:

- A detailed description of the problem's context which will, at the least, include the current situation and background information
- A character who plays the central role and is facing a problem that is to be solved
- Supporting data, this can include; data tables, quoted statements from the various actors in the case, supporting documents, technical diagrams, images, video, or audio
- The case is not required to provide any analysis or conclusions

Students working on the case during the classroom activities focus on analysing the case to understand and explain the events, evaluate and propose solution options to solve the problem, predict the effects of taking actions, etc. The activities involve the following four steps [7]:

1. Understanding the case and identifying the important facts of the case
2. Analysing the case by understanding the issues and challenges from multiple perspectives, and evaluating solutions proposed in the case
3. Taking action by proposing alternate solutions, and evaluating the pros and cons of the solutions and their short- and long-term impact
4. Finally being able to "take away" the generalizable concepts and principles from the case

The activities can differ depending on the course taught. For example, in a management-oriented course, an activity can be answering discussion questions pertaining to the case, "Should the marketing manager launch the product?" In a technology oriented course, an activity can include the students having to design and evaluate solutions, "Propose and evaluate two alternative IT solution architectures for implementing the automated fulfilment process".

Case teaching method provides a number of benefits to enhance student learning through "interactive pedagogy" by stimulating critical thinking and problem solving skills, and by creating reasonably realistic replicas of actual situations--which include incomplete information, time constraints, and conflicting goals [16]. This enhances student motivation and provides a well-aligned learning environment, where practice and theory come together. This is especially true when teaching technical topics through traditional lecture that is often very dry and boring. Following are some benefits of using cases in computing education:

- Helps to introduce real world scenarios and problems into the classroom
- Convey knowledge of what computing professionals do and how they work
- Develop effective problem-solving skills which are situated in a real world context
- Helps students to better connect theory and practice
- Enhance cooperative learning skills in the class

Case-based pedagogy places students at the centre of the learning process. Therefore, from the student perspective, the case study pedagogy provides a number of benefits, namely foster higher levels of critical thinking, enhance practice in professional decision-making, increase practical knowledge, develop analytical and problem solving skills, and analyse problem situations at various levels of abstraction and from multiple points of view [13].

Traditional case-based pedagogy has widely been used in business, medicine and law. More recently, case-based pedagogy has been applied to computer science and engineering disciplines [1], [2] [3] and [14]. More specifically, software engineering curriculum have adopted cases to motivate and enhance student learning. Sowmya et al., have used cases when teaching the various phases of a software project that uses open source tools, namely requirement analysis, planning and scheduling, design and coding, testing, deployment and management [17]. Garg et al. developed a Case-Oriented Learning Environment (COSEEd) for teaching Software Engineering concepts to undergraduate and graduate students in a first course of Software Engineering. COSEEd provides a complete learning environment framework, consisting of pedagogy, learning objectives and assessment targeted at Software Engineering [11]. Besides teaching software engineering methodology, certain theoretical topics such as complier design are also good candidates for the case-based pedagogy. The use of real world cases can make these concepts more relevant and thus motivate the students [4]. Furthermore, integrating projects with cases has seen to provide enhanced students skills of learning, critical thinking, engagement, communication skills and teamwork [4]. In our work, instead of projects, we have integrated cases with hands-on lab work.

Ilse and Shankararaman have proposed four different models in using case-study methodology to design, implement and deliver university-level technology centred computing courses [8]. The first model is primarily based on using Harvard-style, largely management-focused case studies in delivering computing courses. The second model uses an alternative to Harvard style case studies, namely, creating own case studies written and fine-tuned for a given specific course. The third model is based on the concept of "mini-stories" or "mini-cases" that supports designing, implementing and executing laboratory components, particularly, technology-centred computing courses. The fourth model utilizes exclusively student-created case studies. Our work reported in this paper is based on the third model, which uses "mini-cases".

A key challenge in the success of the case-based pedagogy is the quality of the case. In order to develop effective high quality cases, the case writer needs to have both disciplinary and real-world skills. Bolinger et al. proposed an approach for constructing case study teaching materials relevant to the software engineering domain [9]. They developed a script that one can follow to generate the majority of a complete case study. The script comprises three sections namely context, software engineering process, and analysis and design. In our work, to some extent, we attempt to circumvent this challenge by making this process easier, by using mini-cases.

Unlike a regular case, a mini-case is shorter, usually 1-2 pages long. It addresses one learning outcome, may elicit one point of view and may not be a story or scenario that really happened, but realistic enough to drive home the learning objective. It usually takes lesser time to write and can be delivered in a 15-30 minute session.

Julie and Karen recommend the use of mini-cases in training situations where the learners must have sufficient time necessary to absorb and apply knowledge and skills, but at the same time keep the training event short enough to match the limited attention spans of the audience [10]. They propose the following guidelines for writing engaging mini case studies:

- Selecting a story line that replicates the reality
- Minimizing background information so that the learners can jump straight into diagnosing problems and exploring solutions
- Asking pointed questions aligned with the intended learning objective
- Having one to three believable and relatable characters
- Narrating in first person from the point of view of the protagonist
- Including a variety of media such as text, images, audio and video
- Organizing learners into small groups to discuss the case study

In our mini-case pedagogy, we have adopted several of these guidelines and further integrated them with hands-on activities through lab sessions.

Mini-cases are also suited for courses where the students have to learn a number of hands-on analysis techniques. Harold has applied it successfully in a course on Public Policy Analysis, which encourages the students to make decisions about policies, practices, and procedures based on systematic analysis using techniques such as linear regression, sampling, validity, and reliability [6]. A mini-case can help to demonstrate the real world application of a technique. In our work, we use mini-cases to demonstrate the real world application of technology concepts related to enterprise integration and subsequently link them to hands-on labs using specific technologies.

Lisa has used mini-cases to enhance interaction in a large lecture [12]. She developed a series of mini-cases that are implemented with little advance preparation from the students within a 10 to 15-minute window during lecture. In our work, we follow this approach and further align the cases to the lab work.

III. Design of the Mini-Case Pedagogy

In this section we present the mini-case design framework and the delivery model.

A. Mini-Case Design Framework

The design of the mini-case should include four elements namely learning objectives, story, tasks and technical background.

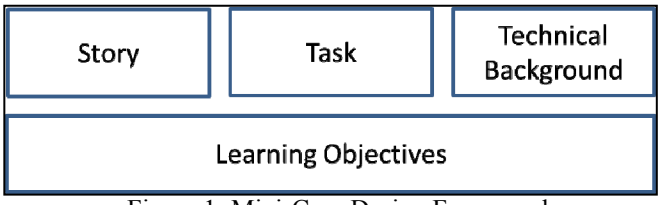

Figure 1: Mini-Case Design Framework

The learning objectives should be focused, narrowly defined, and where applicable the objective should map with the subsequent hands-on lab work. Ideally each mini-case should have only one or two objectives. An example learning objective; "Explain the difference between custom, commercial-of-the-shelf and legacy applications".

The mini-case should have a compelling story line, and address a realistic problem that is similar to those learners will face on the job. In some scenarios a series of events must be described which build the story's tension until the lead character reaches a point where he or she must take some action. For example, "Mariota was awakened in the middle of the night by a phone call from LGB Bank's internal IT support desk. A bank wide production problem affected both retail and corporate customers, and the incident management team suspected that the new Service Mediation Application (SMA) was the source of the problem. Since the whole bank was affected, the Global CEO of LGB Bank was informed, and now Mariota, as the expert, was under pressure to resolve the production problem as quickly as possible."

Unlike a regular case, the mini-case should have minimum background information so that learners can jump straight into studying the problem and exploring solutions.

The mini-case should have few tasks that can be done by the learners during a class session. These tasks can be specified as questions that require students to draw a diagram, fill in a table, questions that ask the learner to define the benefits, limitations, justifications or come up with new ideas. For example, "Read the business scenarios and fill the messaging patterns table by mapping the scenarios to the most suitable Java Messaging Pattern". In some instances, one or two of these tasks can be the precursors for the lab work.

The tasks can be aligned with some of the levels of Bloom's Taxonomy as shown in Table 1 [12].

Table 1: Task Mapping to Bloom's Taxonomy

Task Description	Blooms Taxonomy
With the implementation of the integration middleware, what was the percentage increase in the stock quotes that could be processed in a day?	Recall Questions-Remembering
What was the root cause of the integration problem faced by SingCarRental?	Demonstrate Understanding-Understanding
How can the concept of service be applied to solve the integration problem faced by SingCarRental	Apply the knowledge in real world scenario-Applying

If required, the mini-case can include an appendix section which contains some description of the technology background that students can refer to solve the tasks. For example, a mini-case on the "Application of Text Analytics" can have a summary explanation of the techniques such as "Parts of Speech Tagger", "Sentence Tokenizer", etc. Usually, this appendix section is most suitable for mini-cases that have follow-on lab work.

The mini-case design framework can be adapted by the instructor to specific needs of the course that is being taught.

B. *Mini-Case Design Process*

Figure 2 shows the process for designing the mini-case. There are four steps.

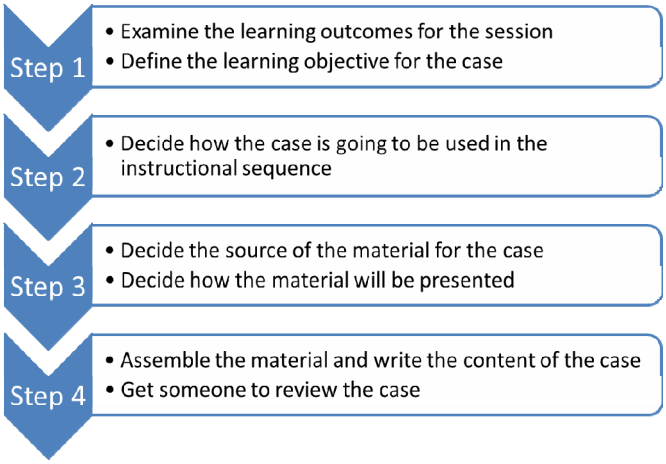

Figure 2: Mini-Case Design Process

Step 1, select one learning outcome of the session and define the learning objective for the mini-case such that it is aligned with the selected learning outcome. Step 2, decide how the case will be used in the instructional sequence. For example, before or after the lecture on the concepts, before or after the labs. Step 3, decide the source of the raw material for the case. From our experience, we have obtained material for the case from many different sources; through discussion with a real-world expert; industry case studies found in company websites; consultancy projects done by instructor; final year student projects. Step 4, assemble the material and write the case. During this step, decisions have to be made on how to present the case. We have found the narrative style works well. In this style, a problem situation is described and a sequence of events develop the story.

C. *Mini-Case Delivery Model*

Figure 3 shows the delivery model for the mini-case pedagogy. The time shown is based on a 3-hour face-to-face class session with about 40-50 students in the class. The timing can be adapted to suit the length of the class sessions. If required, more than one iteration of the phases can be achieved in one session. The delivery comprises of five phases. The timing for each phase can be adjusted depending on the content being covered and practical constraints of the class session.

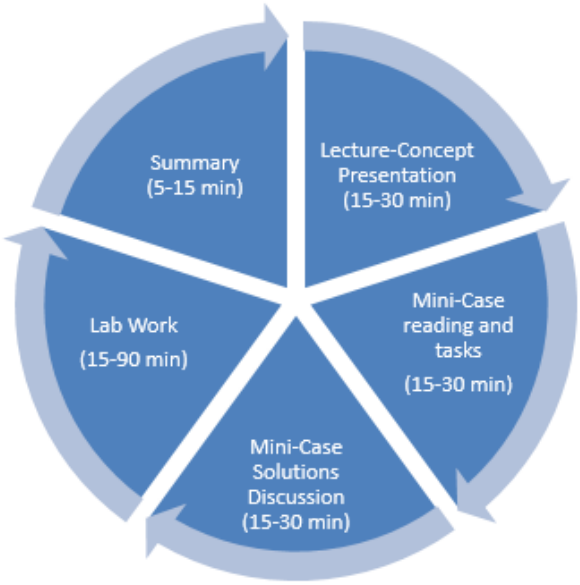

Figure 3: Mini-Case Delivery Model

In Phase 1, the instructor covers the concept through lecture discussion. For example the "Service" concept within the enterprise integration course. About 15-30 min can be allocated for this phase.

In Phase 2, students are asked to read the mini-case. Typically 10 minutes for reading the 1-2 pages of the mini-case. Following this the individual student is required to work on the tasks. In some scenarios, students can be asked to work in a group of 2-3 to solve the tasks. About 15-30 min can be allocated for this phase.

In Phase 3, the instructor will discuss the solutions to the tasks, when appropriate, a particular student or group will be asked to share the solution. About 15-30 min can be allocated for this phase.

In Phase 4, using the standard solution as a basis, the students will work on the labs, perhaps using software tools. The lab sessions can vary from 15-90 min depending on the technical complexity.

In Phase 5, the instructor will provide a summary that links the lecture discussion with the mini-case and the lab. Usually this will require 5-15 min.

IV. IMPLEMENTATION OF MINI-CASE PEDAGOGY

A. *Enterprise Integration (EI) Course Details*

The mini-case pedagogy was implemented in the "Enterprise Integration Course". This course is taught in Term 2 of Year 2 to students doing the Information Systems Major. The overall objectives of the course are as shown in Table 2.

Table 2: Enterprise Integration Course Objectives

Course Objectives
1. Understand and execute a methodological approach to developing a technical architecture for automating a given business process
2. Understand the various technology building blocks of an enterprise integration solution
3. Select appropriate integration technologies for satisfying the integration need of an organization
4. Design and implement an enterprise integration solution by using appropriate integration software tools

The course is spread over one term comprising 14 weeks. Each week there is one 3 hour face-to-face session. The lecture discussion, mini-case and lab work are all conducted within this 3 hours. The class size is around 45 students. The topics covered along with lab work and mini-case for each session is as shown in Table 3. Term-break, project presentation and revision weeks are not shown in this Table. The course involves hands-on lab work using different real world software tools from open source and software vendors which include TIBCO Enterprise Messaging Service, Altova Liquid XML, NetBeans and TIBCO Business Works.

Table 3: Enterprise Integration Course Schedule Details

Wk	Topic	Mini-Case	Lab Work
1	• Business Process and IT Applications • Introduction to Message Oriented Middleware	• Categories of IT Applications • Messaging in the Stock Market	Java Messaging Service (JMS)-Part 1
2	Message Oriented Middleware	• Messaging Patterns • Real World Stock Exchange Using MOM	Java Messaging Service (JMS)-Part 2
3	XML	Book Store	Creating XML Documents
4	Enterprise Integration (EI)	EI in a Retail Company	Implementing EI using JMS
5	Business Processes and Internet of Things (IoT)	• IoT in Port • Insurance Process and IoT	Triggering a business process using a sensor
6	• Service Concepts • REST Web Service • Data Transformation using Integration Middleware (IM)	• Car Rental Integration Problem • Book Store Data Transformation	• REST Web Service • Transformation using IM
7	End-to-End Integration	Book Store End-to-End Integration	End-to-End Integration using IM
8	Adapter/Plugin	Pharmacy Store Plugin selection	Integrate using Plugin
9	• SOAP Web Service • Service Oriented Architecture (SOA) Layers	• SOAP Atomic Web Service in a Bank • Process Web Service in a Bank	• Develop an atomic SOAP WS using IM • Develop a Process Web Service by invoking an Atomic Service using IM
10	Service Oriented Architecture (SOA) Evolution	SOA Evolution in a Bank	None

B. *An Example of Mini-Case Pedagogy from EI Course*

In this section, we will discuss how the mini-case pedagogy has been applied within a specific 3 hour session. For the purpose of this paper, we choose week 9. The main objectives for this session are:

- Understand the concept of atomic and process services and how they form the SOA layered architecture
- Implement an atomic service using integration middleware (IM)
- Implement a SOA solution using IM that uses atomic and process services

During the 3 hour session in Week 9, two iterations of the mini-case pedagogy is applied and is structured as show in Table 4.

Table 4: Week 9 Mini-Case Pedagogy Implementation

Task Description	Timing (mins)
Iteration 1:	
Lecture: SOAP Atomic Web Services (WS)	20
Mini Case 1:SOAP Atomic Web Service in a Bank	20
Mini Case 1 Solution Discussion	10
Lab 1: Develop an Atomic SOAP WS using IM	40
Summary	10
Iteration 2:	
Lecture: Process Service and SOA Layer Architecture Overview	20
Mini Case 2: Process Web Service in a Bank	10
Mini Case 2: Solution Discussion	10
Lab 2: Develop a Process Web Service by invoking an Atomic Service using IM	20
Summary	20
Total Duration	180

Iteration 1 starts with a lecture discussion which helps the students understand the concepts of an Atomic SOAP web service. The students are then expected to read the first mini-case. This mini-case describes the integration challenges in a Large Global Bank (LGB) and how the use of Atomic SOAP Web Service (WS) helps to solve this challenge. Figure 4 shows a snippet from the Mini Case 1: SOAP Atomic Web Service in a Bank. The sample questions which the students are required to tackle as part of this mini-case is also provided as part of the mini-case. Michael Tan and Mark are characters in the mini-case study.

LGB Bank is a large global bank headquartered in New York, with a large regional presence in Asia. The bank is currently embarking on a process of reengineering the loans process for all the different products (home, auto and life) and are keen to leverage the concept of "services" in the implementation of the re-engineered processes.

Mr Michael Tan, the Chief Architect had recently attended a session on SOAP web services. In spite of being more complex when compared to REST WS, he is keen to use them in the bank due to the following reasons:

…

Mr Tan decided that the project will be divided into two phases:

Phase 1: Develop a SOAP WS for getting product information from the core banking product database using the IM (TIBCO BW)

Phase 2: Develop a process for the home mortgage interest calculation that will reuse the SOAP WS using the IM (TIBCO BW)

- Develop a SOAP WS for getting product information from the core banking product database using the IM (TIBCO BW)
- The first question is, what should be exposed as a service? Having learnt the concept of service, it was clear that any functionality that can be reused should be exposed as a service. One of the functionality that often tends to be reused is the functionality to get the product details from the core banking product data base. The product data base, "corebank" has the table "Product" that contains details about the different products namely CASA, TD 5 Year, Home Loan, Auto Loan, etc.

Since SOAP WS is complex, the LGB developer Mark uses the TIBCO BW to develop this service using the data stored in the "corebank" DB. Mark develops a Product_Info web service that supports four different service operations, namely read, update, create and delete on the "Product" table. He first implements the ProductInfo_Read, which corresponds to "read" operation. In order to do this, he develops the operation logic using a process flow in integration middleware (IM) TIBCO BW.

…

Based on the mini case, reflect upon the following questions:

1. Why did Mr Tan choose SOAP WS over REST WS for the bank?
2. What is the difference between the service and a service operation?
3. How did Mark implement the service operation logic?
4. What are the advantages and disadvantages of the implementation approach adopted by Mark?
5. Examine the SOAP request and response messages

Figure 4: Snippet of Mini Case 1: SOAP Atomic Web Service in a Bank

The answers to these questions are then discussed by the instructor. The discussions lead to the hands-on lab session, where the students implement the Product_Info web service using the integration middleware tool. On completing the lab, the instructor will summarize the session by discussing the relationship between what the students did in the lab to the concepts covered in the lecture and real world context in the mini-case. This will help to drive home the point, the practical relevance of what the students have learnt.

Iteration 2 starts with a lecture discussion which helps students understand the concept of "process services", and how these services along with the user interface channels, atomic service and back-end IT applications form the layered service oriented architecture (SOA) in order to enable business process automation. The layered SOA architecture that the students are expected to understand is as shown in Figure 5.

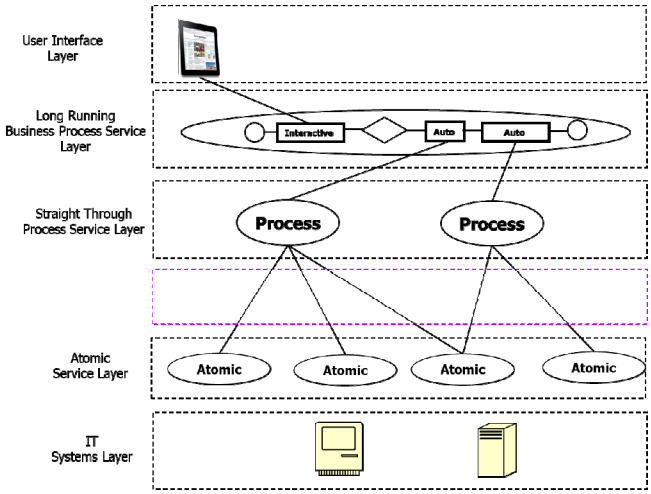

Figure 5: SOA Layers

The mini-case for this iteration follows the pervious mini-case by extending the scenario to include a process service. Following are some sample questions from mini-case 2:

1. How is the Mortgage Interest Rate process triggered?
2. How did Mark invoke the Product_Info SOAP WS?
3. Is Mortgage Interest Rate process a web service? If yes, then
4. Is it a SOAP or REST WS? Justify your answer.
5. What type of service (atomic or process) is it? Justify your answer.
6. Map the Product_Info service and the Mortage Interest Rate process services on the appropriate layers in the SOA layered architecture.

Similar to Iteration 1, the solutions are discussed followed by the hands-on lab. In this lab the students implement the Mortage Interest Rate process service using the integration middleware. On completing the lab, the instructor will summarize the session by discussing the two labs and how they are related to each other and how they relate to the

concept of atomic and process services, and the SOA Layers. The instructor will also highlight the real world context of the bank that is used in the two mini-cases.

V. Evaluation Survey Results

In this section, we will share the mini-case pedagogy experiences from the two stakeholders; students and instructor.

In order to gather student feedback, an online survey was conducted in class during the last week of the course. 200 students participated in the survey. Table 5 shows the details of the questions used in the survey.

Table 5: Questionnaire for Survey

Question
Questions 1, 2 and 3 use the scale: Extremely Useful-Very Useful- Moderately Useful-Slightly Useful-Not Useful
1. Rate how useful the mini-cases were in providing a context (scenario) for the labs
2. Rate how useful the mini-cases were in helping you gain a better understanding of the concepts taught in the course
3. Rate how useful the labs were in helping you gain a better understanding of the concepts covered in the lecture
Questions 4, 5 and 6 use the scale: Strongly Agree- Somewhat Agree- Neither Agree nor Disagree- Somewhat Disagree- Strongly Disagree
4. The mini-cases and labs were aligned in terms of the learning objectives and concepts covered
5. The lecture content and labs were aligned in terms of the learning objectives and concepts covered
6. The lecture content, labs and mini-cases were aligned in terms of the learning objectives and concepts covered
Question 7 seeks qualitative comments
7. Give your suggestions on how to improve the use of mini-cases and labs in the enterprise integration course

Questions 1, 2 and 3 emphasise the usefulness of the mini-case, lecture and labs in reinforcing the concepts learned. Questions 4, 5 and 6 emphasise the extent of alignment in terms of the learning objectives and concepts, between the three elements namely lecture content, mini-cases, and labs. Following are some conclusions from the survey data:

- The mini-cases provided the necessary context for learning the concepts covered in the lecture. 62% of the students found it to be “Extremely Useful” and “Very Useful”. Another 34% found it to be “Moderately Useful”.
- The mini-cases were useful in helping the students gain a better understanding of the concepts covered during the lecture session. 64% of the students found it to be “Extremely Useful” and “Very Useful”. Another 32% found it to be “Moderately Useful”.
- The labs were useful in helping the students gain a better understanding of the concepts covered during the lecture session. 63% of the students found it to be “Extremely Useful” and “Very Useful”. Another 28% found it to be “Moderately Useful”.
- There was good alignment between the mini-case and the hands-on labs. 84% of the students either “Strongly Agreed” or “Somewhat Agreed”. About 12% remained neutral.
- There was good alignment between the lecture content and the labs. 87% of the students either “Strongly Agreed” or “Somewhat Agreed”. About 10% remained neutral.
- There was overall good alignment between all the three components namely the lecture content, mini-cases and labs. 92% of the students either “Strongly Agreed” or “Somewhat Agreed”. About 10% remained neutral.

Table 6 shows some of the suggestions given by students to further enhance the mini-case pedagogy.

Table 6: Student Suggestions

Group	Suggestions
1	• Some of the mini cases are not very mini, so I think it's better to summarise the cases or cut out irrelevant materials from the cases to make it easier to digest and understand. • More mini cases to be used to explain the concepts. • Mini-cases can have more details about the explanation and solution. • If possible, the mini-cases can be on companies which we are more familiar with. • Probably allocate more time to reading the mini cases and spend more time on it. Felt that the time allocated for labs overshadowed those of mini cases.
2	• Can get students to discuss and come up with other potential applications as well. • Improve the mini cases by having students to draw a technical diagram. • Maybe assign students weekly to present each mini case so that all students can learn from each other during the presentation.
3	• Tailor the mini-case and labs to more on how we can actually apply these concepts in the project. • Would recommend changing the project to fit the labs and mini-cases

The student suggestions are grouped into three categories. Category 1 refers to suggestions related to enhancing the mini-case design. Category 2 refers to suggestions on how the instructor can further enhance the student interaction when the solutions are discussed. Category 3 refers to suggestions related to linking mini-case and lab to the group project assessment that the students are required to complete.

Informal interviews were conducted with the instructors teaching the enterprise integration course. The following is a summary of the conclusions from these interviews:

- The instructors found that the mini-cases were useful in helping them break the monotony of the lecture session.
- After having done the mini-case, the students seemed to be better prepared in doing the lab work. This reduced the number of queries that were addressed to the instructors during the lab session.
- One of the instructors highlighted the fact that the enhanced alignment between lecture content, mini-

cases and labs provided him with multiple options to clear student misconceptions by using references to the mini-case or lab. However, the instructor also alluded that any change in one component (e.g. mini-case) will require corresponding changes to the others, thus requiring additional effort from the instructor.

- One of the instructors highlighted that the mini-cases and labs provided the context that can be referred to when clearing student doubts prior to exam.
- In some sessions, the instructors found it difficult to keep to the time allocated for the mini-case discussions.

VI. CONCULSIONS

In technology courses, it is essential to teach concepts and principles but at the same time the students need to understand how to translate and apply what they learn into real-world activity. One pathway to achieving this is through the use of mini-cases and hands-on labs. In this paper, we presented a mini-case pedagogy that attempts to align lecture discussions, mini-cases and hands-on labs. We have applied this pedagogy to the "Enterprise Integration" course.

Our findings show that the students found the mini-case pedagogy to be very useful in the following three ways; firstly, the mini-cases provided the necessary context for learning the concepts covered in the lecture. Secondly, it enabled the students gain a better understanding of the concepts covered during the lecture session. Thirdly, the labs enhanced the understanding of the concepts covered in the lecture.

Based on the student feedback, our future work will address five issues namely, alignment of the mini-cases and labs with the project assessment, further refine the mini-cases so that they are brief and to the point, and explore different mechanisms to enhance student discussion and presentation of mini-case solutions in the class, conduct survey in the next run of the "Enterprise Integration" course to further verify the benefits of the mini-case approach, and application of the mini-case pedagogy to other technology intensive courses in the curriculum.

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