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Case Studies: Developing Financial Mathematics' Systems

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Abstract: In this research, we introduce four case studies corresponding to the development of four Financial Mathematics' Systems using Object-oriented Analysis and Design (OOAD). These systems were developed by undergraduate accounting students at Santa María University in Barinas, Venezuela. While Microsoft Excel is not an Object-oriented Programming (OOP) language, it was used by the students to develop these systems. In fact, Microsoft Excel is widely applicable in the accounting community. Consequently, an exploratory multiple case design was utilized and a comparison analysis was performed; a methodology for creating case studies was developed and implemented, and finally, a conclusion and recommendations were provided.

Keywords*: Case Study, Financial Mathematics, Object-oriented (OO), Microsoft Excel*

JEL Classification*:* G30, M41, M15

1. Introduction

There is a famous Chinese proverb that highlights that a journey of a thousand miles begins with a single step (Chinese Proverbs, 2015). Therefore, let's walk toward the object-oriented paradigm by taking a single step and denoting the idea of an object. In a nutshell, an object is a tangible or intangible item that can be visualized (Wu, 2010). Similarly, an object is a software collection of interrelated states and behaviors (Phuong, 2012). Objects are items that combine the attributes of procedures and data since they execute computations and save local state (Stefik & Bobrow, 1985). In practice, software objects are frequently used to model real situations from everyday life (Phuong, 2012). The objects represent the key ingredients to grasp object-oriented technology.

Similarly, understanding the concept of a class is a key notion required to comprehend object-oriented technology. A class is a blueprint from which objects are created. Likewise, a class is a sort of mold or pattern that dictates what objects can and cannot perform (Wu, 2010). As a result, the creation of an object as a member of a class is called the instance of the class (Wu, 2010).

Some of the additional concepts required to grasp the object-oriented technology include the following ideas.

Abstraction: It means to concentrate on the basic features of the object, disregarding its unimportant properties;

Concurrency: It allows executing multiple objects simultaneously;

Hierarchy: It deals with breaking the system into subsystems using a top-down fashion and having all the subsystems interrelated;

Interface: It defines the interactions of the objects with the outside world through their methods (Phuong, 2012);

Package: It organizes a set of related classes and interfaces (Phuong, 2012);

Encapsulation: It deals with hiding the internal details of a class from the outside world; and

Modularity: It means decomposing a problem into pieces in order to achieve efficiency.

The world economic downturn has created an unemployment situation that affects the quality of life of many people around the globe. That is why there is a need to find better jobs and better quality of life (OECD, 2012).

As a result, the skill of combining Financial Mathematics with Accounting using Microsoft Excel was consolidated through the development of the Financial Mathematics' Systems as highlighted in this paper. Therefore, this innovative skill generates new job opportunities for people in the international business landscape. For that reason, this paper was crafted.

Accordingly, the rest of this paper is organized into the following sections: (2) Research Questions and Hypotheses; (3) Illustrations of Mathematical Formulations; (4) Seminar in Developing Systems with Microsoft Excel; (5) Workshop in OOAD; (6) Case Studies; and (7) Conclusion and Recommendations.

2. Research Questions and Hypotheses

The review of the undergraduate courses of Financial Mathematics I and Financial Mathematics II at Santa María University in Barinas, Venezuela has revealed the following three gaps: 1) there is a need from the accounting students to integrate Financial Mathematics with Accounting and Microsoft Excel, 2) there is a need from the accounting students to learn how to develop a system using Microsoft Excel, and 3) there is a need from the accounting students to learn how to perform an analysis and design of a system using an approach such as OOAD.

In order to address the aforementioned gaps, it was necessary to find answers to the following research questions.

RQ1: Can undergraduate accounting students apply OOAD to analyze and design Financial Mathematics' Systems?

RQ2: Can undergraduate accounting students use Microsoft Excel to develop Financial Mathematics' Systems?

After defining the research questions, the next step was to introduce a theoretical framework of the study, highlight the research variables, and present the hypotheses. Consequently, this entire research structure provides the basis for finding answers to the aforementioned research questions.

According to Sekaran (2003), the theoretical framework depicts the association of the research variables under study.

The theoretical framework of this research is presented in Figure 1. This conceptual framework helps to postulate or hypothesize the interrelationship of the research variables of this study. As part of the theoretical framework, there are three variables: Financial Mathematics' Systems, Microsoft Excel, and OOAD, along with two hypotheses: H1 and H2.

Consequently, Figure 1 shows the interrelationship between the independent variable OOAD and the dependent variable Financial Mathematics' Systems. Similarly, Figure 1 depicts the interrelationship between the independent variable Microsoft Excel and the dependent variable Financial Mathematics' Systems.

Therefore, this research introduces the following two hypotheses.

H1: OOAD does not support the analysis and design of Financial Mathematics' Systems and

H2: Microsoft Excel does not support the development of Financial Mathematics' Systems.

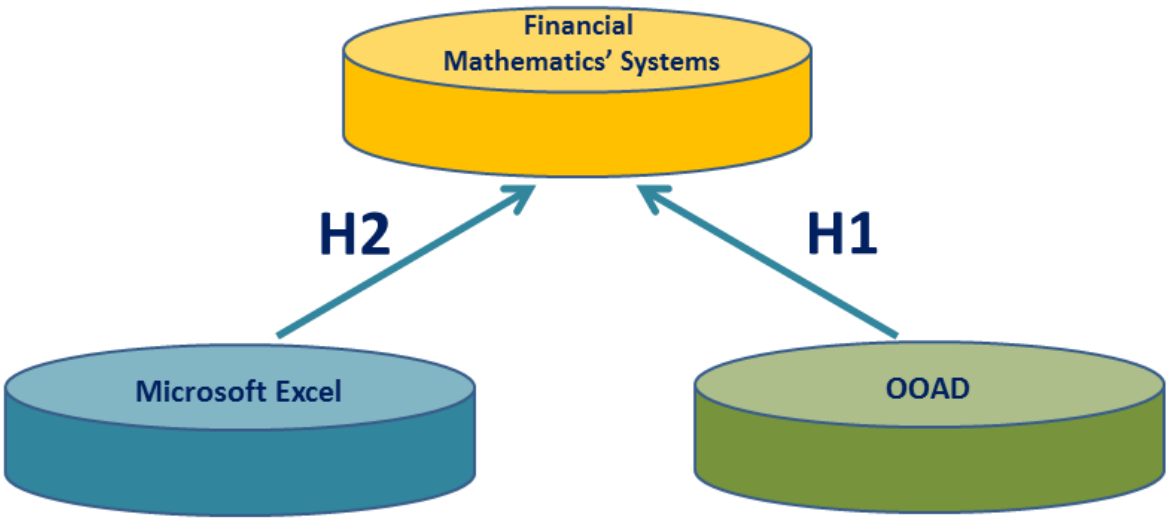

Figure 1 Theoretical Framework

Looking at the research questions and hypotheses in a perspective relationship, Figure 2 illustrates the link between the research questions and hypotheses as follows.

Research Questions	Hypotheses
RQ1: Can undergraduate accounting students apply OOAD to analyze and design Financial Mathematics' Systems?	**H1:** OOAD does not support the analysis and design of Financial Mathematics' Systems
RQ2: Can undergraduate accounting students use Microsoft Excel to develop Financial Mathematics' Systems?	**H2:** Microsoft Excel does not support the development of Financial Mathematics' Systems

Figure 2 Research Questions and Hypotheses Relationship

Consequently, research question RQ1 leads to hypothesis H1 and research question RQ2 leads to hypothesis H2.

3. Illustrations of Mathematical Formulations

Furthermore, some of the key mathematical formulations used to develop the Financial Mathematics' Systems are highlighted as follow.

3.1 Formula A

$$D = (C - S) / N \quad (1)$$

Where D is the straight line method of depreciation, C is the original cost of an asset, S is the salvage or scrap value, and N is the estimated useful life.

3.2 Formula B

$$SYD = (R/ S) \times O \quad (2)$$

Where SYD is the sum-of-years-digits method of depreciation, R is the remaining life of the asset, including the current year, S is the sum of all digits of the life of the asset in years, and O is the original cost of the asset.

In that sense, depreciation is a book method (noncash) used to reduce the value of a tangible asset (Blank & Leland, 2012).

3.3 Formula C

$$EOQ = \sqrt{\frac{2 \times D \times O}{H}} \quad (3)$$

Where EOQ stands for the economic order quantity of inventory, which is the optimal order quantity, D is the annual demand of a product, in units, for an inventory item, O is the ordering cost per order, and H is the holding cost per unit per year.

In fact, EOQ indicates how much to order.

Therefore, inventory is one of the most important assets of companies in today's business world and it is used to satisfy actual and forthcoming demand.

3.4 Formula D

$$ROP = D \times L \quad (4)$$

Where ROP stands for reorder point of inventory. ROP indicates when is the right time to order more stock. In that sense, D is the average daily usage rate and L is the lead time in days.

3.5 Formula E

$$NSI = NS / AI \quad (5)$$

NSI is the turnover of inventory to net sales. NS is net sales and AI is the average inventory.

3.6 Formula F

$$NCF = R - D \quad (6)$$

Where NCF is the net cash flow, R represents the receipts (cash inflows) and D denotes the disbursements (cash outflows).

4. Seminar in Developing Systems with Microsoft Excel

In order to enable the students with programming skills, a seminar was conducted in Developing Systems with Microsoft Excel. Such seminar was delivered in four hours. Thus, students from Financial Mathematics I and Financial Mathematics II were invited, in addition to some people from outside of the university.

Nevertheless, we had fourteen participants attending the seminar. One administrative assistant came from the Graduate School department, one student from another university, two professors, and ten students from the Financial Mathematics' classes. Therefore, the agenda of the seminar is displayed in Figure 3.

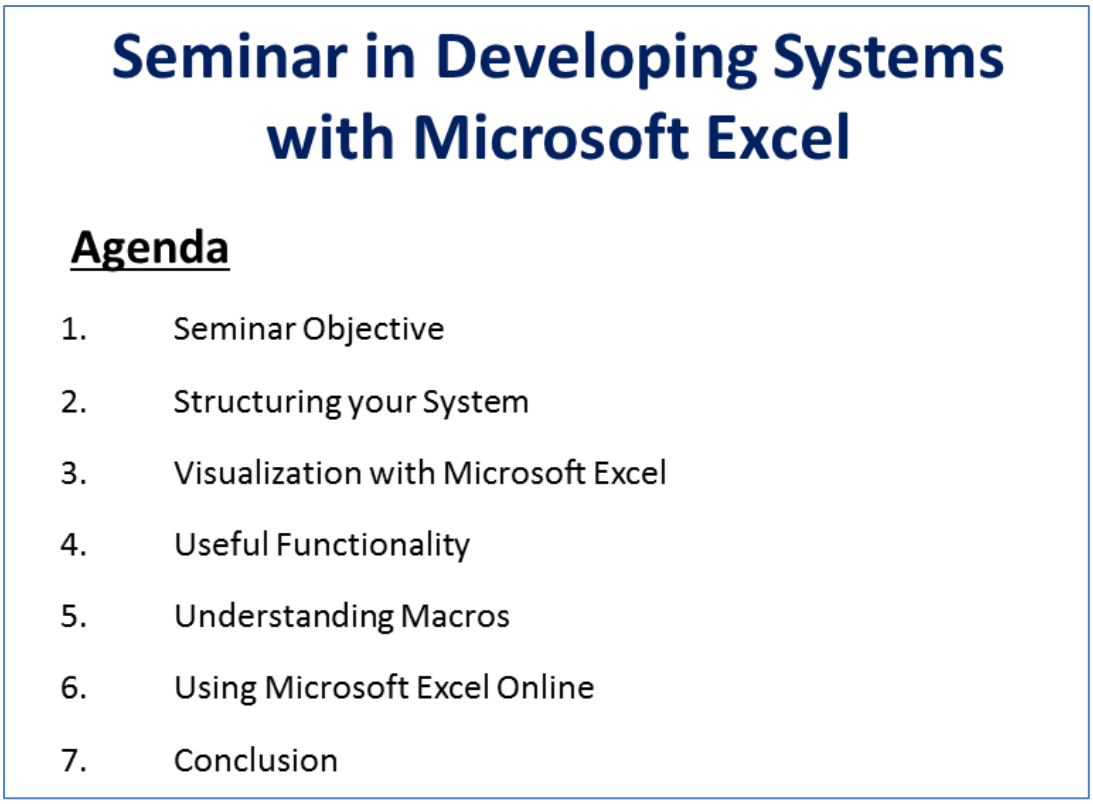

Figure 3 Agenda – Seminar in Developing Systems with Microsoft Excel

As it was outlined in Figure 3, several topics were covered. However, such topics included technical details such as reviewing the idea of the cell data entry; splitting the worksheet into windows; adding graphics as objects; working with multiple workbooks as decomposition strategy; managing worksheets; creating charts and graphics; using formulas and functions; linking workbooks with hyperlinks; building and maintaining data lists; building and running macros; using statistical functions; using financial functions; applying engineering functions; using database functions; applying mathematic and trigonometric functions; and exploring Microsoft Excel Online.

Nevertheless, it is important to mention that VBA programming was out of the scope of this seminar. Nonetheless, we had the following four assumptions.

(1) Participants were required to have some basic experience working with Microsoft Excel;

(2) It was not necessary to have a programming background;

(3) Participants were required to have interest in developing a system with Microsoft Excel; and

(4) Participants needed to have Financial Mathematics expertise.

5. Workshop in OOAD

In order to equip the students with OOAD skills, two workshops (two rounds) were conducted in Object-oriented Analysis and Design. The mentioned workshops were delivered in four hours each. Therefore, students from Financial Mathematics I and Financial Mathematics II were invited to the workshops; nevertheless, on the first round, we had four participants from Financial Mathematics II. Likewise, on the second round, we had four participants from Financial Mathematics I.

Accordingly, the agenda of the workshops is presented in Figure 4.

Figure 4 Agenda – Workshop in Object-oriented Analysis and Design

In order to assist students with their system development effort, an OOAD Template was provided. Consequently, an outline of the template is depicted in Figure 5.

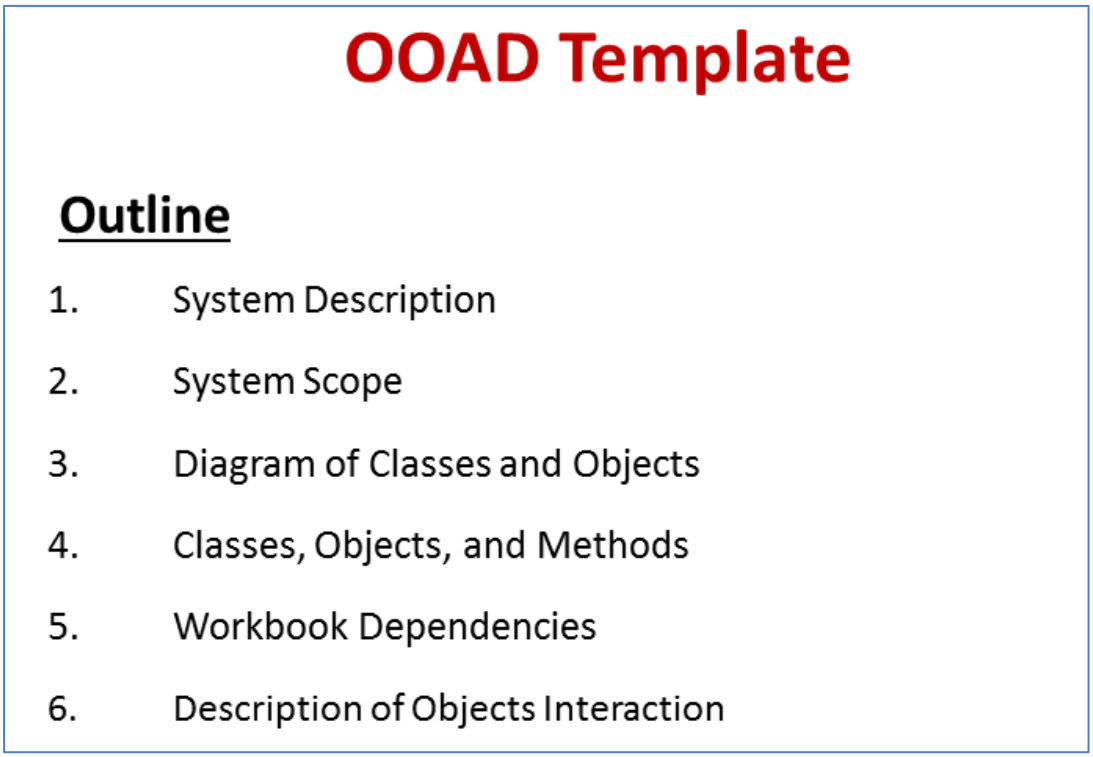

Figure 5 Outline – OOAD Template

6. Case Studies

While there is evidence that case study research has been frequently used in social science fields like anthropology, industrial relations, and sociology (Noor, 2008), a world of opportunities exists in the engineering, economics, accounting, information technology, law, business, medicine, human resources, and the natural science areas.

As a result, the case study research is considered a solid research method that is usually used in a thorough investigation effort (Zainal, 2007).

As highlighted by Noor in 2008, Yin suggested in 1989 that the case study research method is an occurrence, an entity, a specific element, or even a unit of analysis. It is an empirical inquiry that allows you to perform a research on an incident within its real life context using many sources of evidence (Noor, 2008).

Likewise, Baxter and Jack (2008) indicated that Yin denoted in 2003 that case studies can be categorized as explanatory, exploratory, or descriptive. Yin also differentiated between single, holistic case studies, and

multiple case studies. Additionally, Baxter and Jack also highlighted in 2008 that Stake indicated in 1995 that the case studies could be classified as instrumental, intrinsic, or collective.

However, in this particular research, we have adopted an exploratory multiple case design method. This approach allows us to explore if the accounting students were able to apply OOAD and develop the four Financial Mathematics' Systems using Microsoft Excel.

6.1 Case Studies Methodology

In consequence, a methodology was developed to create the case studies. Figure 6 displays the elements of this methodology. As a result, the methodology includes three phases, namely Initiating Phase, Fieldwork Phase, and Closing Phase. Hence, the activities depicted in Figure 6 were performed in each of the phases of the methodology and addressed across this study.

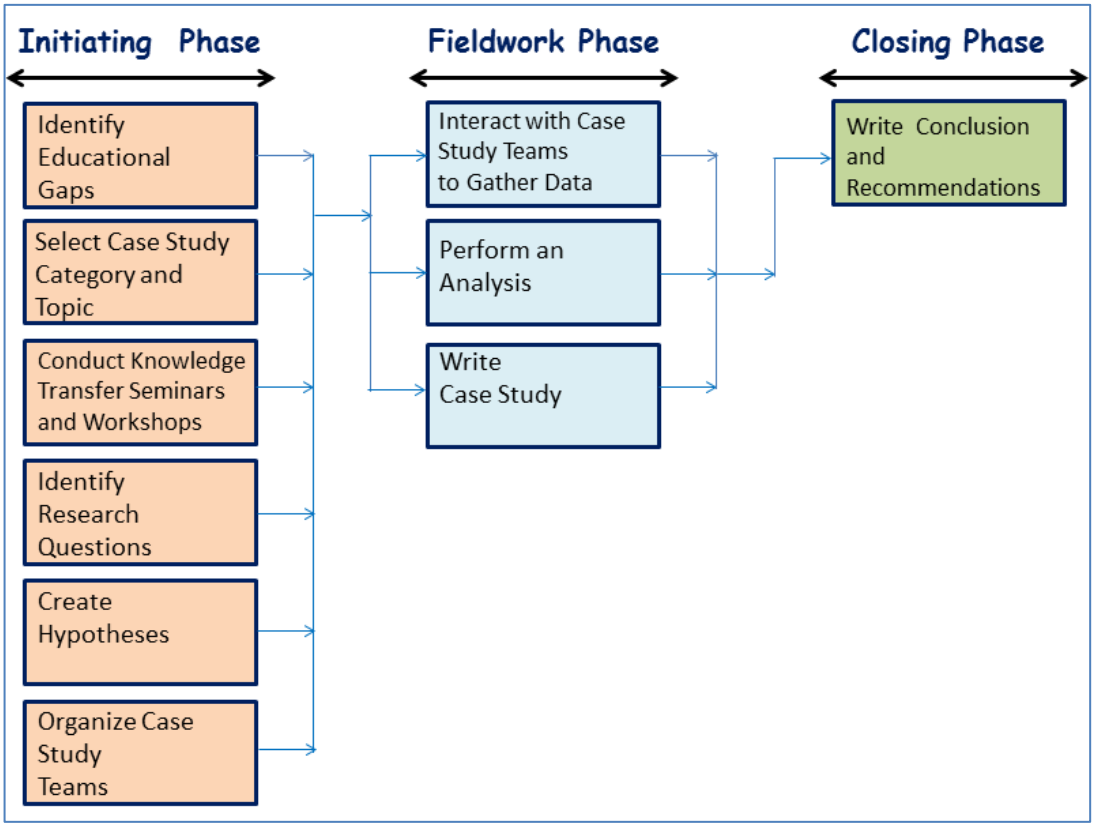

Figure 6 Case Studies Methodology

However, it is important to highlight that an analysis was performed on the case studies in order to gather data and investigate the research questions and hypotheses that were introduced in section 2. Research Questions and Hypotheses of this paper.

6.2 Creating the Case Studies

Therefore, the following case studies were created.

Case Study A: The key stakeholders of this case study were four students coming from the Financial Mathematics I class. Correspondingly, they were attending the fifth semester of the accounting degree program. Such students developed a Depreciation Information System.

Case Study B: The key stakeholders of this case study were four students from Financial Mathematics II. Such students were attending the sixth semester of the accounting degree program. As a result, the students were responsible for developing an Inventory Management Control System.

Case Study C: This case study had four students from Financial Mathematics II. The students were responsible for developing a Cash Flow Management System.

Case Study D: In this case study, a Cash Flow Management System was developed. The key stakeholders of this case study were four students from Financial Mathematics II.

Therefore, we have linked the case studies with the development of the Financial Mathematics' Systems. Consequently, the linkage of the case studies with the Financial Mathematics' Systems is depicted in Figure 7.

Case Studies	Financial Mathematics' Systems
Case Study A	Depreciation Information System
Case Study B	Inventory Management Control System
Case Study C	Cash Flow Management System
Case Study D	Cash Flow Management System

Figure 7 Linkage

6.3 Case Studies Evaluation

6.3.1 Evaluation Criteria

Consequently, Figure 8 summarizes the evaluation effort of the case studies using the following evaluation criteria.

(1) Knowledge of Microsoft Excel;

(2) Attending the Seminar in Developing Systems with Microsoft Excel;

(3) Previous Systems Analysis and Design Experience;

(4) Attending the OOAD Workshop;

(5) Expertise in Using the OOAD Template;

(6) Background in Computer Programming;

(7) Knowledge of Accounting; and

(8) Expertise in Financial Mathematics.

6.3.2 Comparative Analysis

As a result, in the next paragraphs, a comparative analysis of the case studies is described

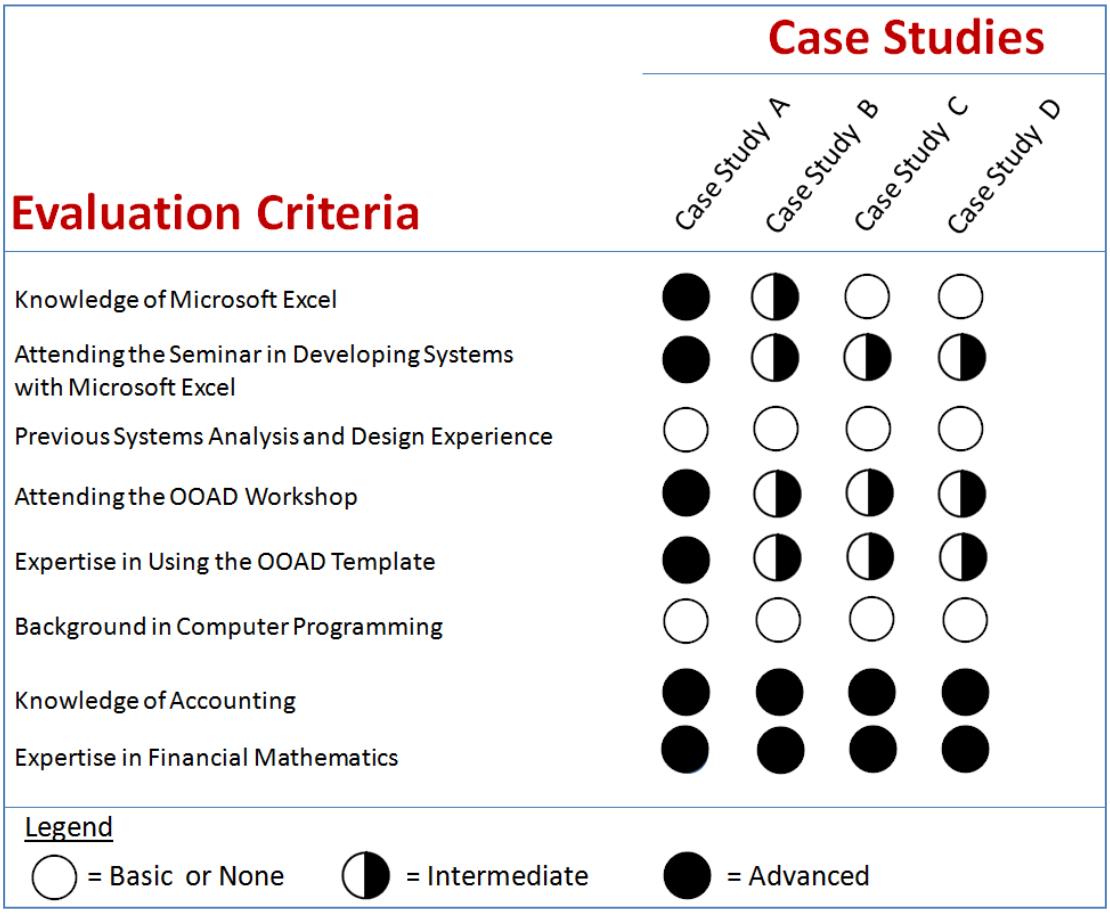

Figure 8 Case Studies Evaluation

6.3.2.1 Knowledge of Microsoft Excel

We noted that all the students from Case Study A had an advanced knowledge of Microsoft Excel. However, the students from Case Study B had intermediate knowledge of Microsoft Excel. Likewise, the students

from Case Study C and Case Study D had basic or none knowledge of Microsoft Excel.

6.3.2.2 Attending the Seminar in Developing Systems with Microsoft Excel

In terms of attending the seminar in Developing Systems with Microsoft Excel, all the students from the Case Study A attended the seminar. Therefore, the evaluation of the Case Study A in this category was advanced. Similarly, some of the students from Case Study B, Case Study C, and Case Study D came to the above seminar. As a result, the evaluation of the Case Study B, Case Study C, and Case Study D in this category was intermediate.

6.3.2.3 Previous Systems Analysis and Design Experience

Due to the fact that all the students from Case Study A, Case Study B, Case Study C, and Case Study D did not have previous experience in systems analysis and design, all the case studies were evaluated as basic or none experience in this category.

6.3.2.4 Attending the OOAD Workshop

While all students from Case Study A attended the OOAD workshop, few students from Case Study B, Case Study C, and Case Study D could attend this practical training. Therefore, Case Study A was evaluated as advanced in this category and the rest of the case studies were respectively evaluated as intermediate.

6.3.2.5 Expertise in Using the OOAD Template

The students from the Case Study A completed the OOAD Template during the OOAD workshop. Likewise, all the students from the Case Study B, Case Study C, and Case Study D completed the OOAD Template on their own time after the workshop. Therefore, the Case study A was evaluated as advanced and the rest of the case studies were evaluated as intermediate in this category.

6.3.2.6 Background in Computer Programming

All the students from Case Study A, Case Study B, Case Study C, and Case Study D did not have any previous background in computer programming. Consequently, all the case studies were evaluated as basic or none background in computer programming.

6.3.2.7 Knowledge of Accounting

All the case studies were evaluated as advanced knowledge of accounting.

6.3.2.8 Expertise in Financial Mathematics

All the case studies were evaluated as advanced expertise in financial mathematics.

6.3.2.9 Summary

In summary, the development of the Financial Mathematics' Systems, along with the evaluation of the case studies provided support to answer the research questions and test the hypotheses of this study.

7. Conclusion and Recommendations

We have completed a research on four case studies corresponding to the development of four Financial Mathematics' Systems. Therefore, this research article was organized into the following sections: Introduction; Research Questions and Hypotheses; Illustrations of Mathematical Formulations; Seminar in

Developing Systems with Microsoft Excel; Workshop in OOAD; Case Studies; and Conclusion and Recommendations

7.1 Rejection of Hypothesis H1 and Hypothesis H2

Consequently, hypothesis H1 stated that "OOAD does not support the analysis and design of Financial Mathematics' Systems" and hypothesis H2 denoted that "Microsoft Excel does not support the development of Financial Mathematics' Systems." Accordingly, the research approach utilized for testing the above hypotheses was the application of case studies. As a result, it can be confidently affirmed the rejection of hypothesis H1 and hypothesis H2.

7.2 Answering Research Question RQ1 and Research Question RQ2

The research question RQ1 stated the following interrogation: "Can undergraduate accounting students apply OOAD to analyze and design Financial Mathematics' Systems?" as part of the Financial Mathematics' classes. Thus, RQ1 had a strongly positive answer of "yes" because of the rejection of hypothesis H1. Furthermore, the research question RQ2 indicated the following inquiry: "Can undergraduate accounting students use Microsoft Excel to develop Financial Mathematics' Systems?" during the Financial Mathematics' classes. Consequently, RQ2 had a strongly positive answer of "yes" because of the rejection of hypothesis H2. Therefore, we conclude that the development of the Financial Mathematics' Systems (Depreciation Information System, Inventory Management Control System, and the two Cash Flow Management Systems) supported RQ1 and RQ2. Likewise, the rejection of H1 and H2 helped to find the answers for RQ1 and RQ2.

7.3 Further Research

In order to complete this study, the following ideas are introduced as a ground base for further research in teaching Financial Mathematics' Systems: (1) develop an undergraduate Financial Mathematics class with Microsoft Software Development Kit (SDK); (2) create an undergraduate Financial Mathematics class with Java programming; (3) deliver an undergraduate Financial Mathematics class with VBA programming; (4) create an undergraduate Financial Mathematics class with C# programming; and (5) conduct an undergraduate OOP comparative analysis class with C++, C#, Ruby, Objective-C, Java, Python, and Delphi.

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