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AN ANALYSIS OF THE IMPACT OF AN INTERDISCIPLINARY PROJECT ASSIGNMENT ON STUDENTS' LEARNING OUTCOMES

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Abstract: *This paper presents the design and analysis of an interdisciplinary experiential learning project to simulate a food manufacturing workplace experience within the course curriculum. The objectives are for students to accomplish various learning outcomes, along with the understanding of professional implications. Using a specific food of choice, small teams collaborated to cook a healthier version of that food for sale at a profit. Evaluation of learning outcomes through the lens of Fink's taxonomy is exploratory and qualitative. At the end of this project, students are able to achieve learning outcomes mainly in the areas of knowledge application, human dimension and integration, and to a lesser extent in the other domains. The project benefits students in a second division course when they are yet ready for industrial internship by providing a hands-on insight on what to expect in their working lives.*

Keywords: *Project-Based Learning, Fink's Taxonomy, Interdisciplinary Collaboration*

Introduction

The contemporary workplace requires graduates to be equipped with capabilities beyond basic literacy and numeracy skills in order to meet the rapid changes in global economy and technology. Also known as soft skills and 21st century learning skills, graduates are expected to be able to collaborate and work effectively in teams, to think critically about issues, solve problems creatively, and communicate clearly in many media (Rotherham & Willingham, 2010). This also means that they have to be flexible and adaptable, to take initiative and lead when necessary, and to deal with a plethora of information. Many Malaysian graduates have been found to be deficient in soft skills, personality and practical competencies, and this has led to their difficulties in getting employment after graduation (Cheong *et al*, 2015). Therefore it is imperative that course curricula are intentionally redesigned to prepare undergraduates to function in their careers.

Traditional lecture-based instruction tends to unwittingly encourage memorization of facts merely for passing exams with little intellectual efforts to critically evaluate and make connections of knowledge to their lives (Fink, 2003; Shank et al, 1999). Lectures also provide little opportunities for the development of skills and competencies. Fink (2003) envisions that when courses introduce an important and lasting change in a student's life, then learning will become significant. Such changes typically involve active learning or "learning by doing" through concrete experience and reflective thoughts which can be traced to Dewey's (1966) experiential learning model. Learning-by-doing when extended to include authentic practice permits the application of theory in practical situations aimed specifically in bridging the gap between student learning and professional practice (Edelson & Reiser, 2006). Authentic practices essentially engage students in a particular profession using real-world examples, complex problems and their solutions through experimentation, role play, case studies, and problem or project based activities in an inherently multidisciplinary learning environment (Lombardi, 2007).

To facilitate a change from the traditional approach, Fink (2003) develops an integrated framework for creating learning-centered courses. This framework triangulates the situational factors with assessment procedures that are linked to teaching and learning activities. He advocates the "backward design" where assessment procedures are thought of before planning teaching and learning activities instead of the reverse order in a forward design. In this way instructors are forced to think about how to determine that learning has taken place. Only then will it become clear what students need to do to show evidence of their achievements in the defined learning goals. This type of assessment is educative since it looks ahead of what is expected as opposed to traditional exams that measure how much students can remember from topics learnt in previous weeks.

The situational factors include a review the nature of the course, characteristics of the learners and instructor, the students' expectations to establish learning goals, and others. Fink conjures that a very pertinent part in selecting the relevant situational factors is to consider the special pedagogical challenge for both students and instructor that will translate into a meaningful learning experience. If teaching and learning activities can find a way to successfully meet this challenge, the chances will be high for learning to become long lasting and significant.

Purpose

Guided by Fink's (2003) integrated course design framework, the instructors respectively of an introductory accounting and nutrition courses in a Malaysian private university decide to incorporate a collaborative project-based learning assignment between them to simulate a food manufacturing experience. These two courses are selected because it is common in the food industry for both accountants and nutritionists to integrate their respective expertise in order to manage fiscal control and make informed decisions on budgeting and product pricing, while ensuring high standards of nutritive quality. Accordingly, this project will present a situation for the integration of the respective disciplinary knowledge to bridge the gap between their learning and the food industry.

Previously the courses were taught through lectures and homework assignments, resulting in a generally low energy class dynamics where rote-learning is common. A change is offered here to engage students in learning-by-doing so that learning can become significant. Hence the main aims of this study is to determine the impact of the project on the types of learning outcome attained and to map the learning outcomes to the learning domains in Fink's taxonomy of significant learning.

Literature Review

Fink's Taxonomy of Significant Learning

The guiding framework in this study is Fink's taxonomy of significant learning (2003). Although Bloom's taxonomy (Bloom *et al*, 1956) has been used regularly to design courses, instructors most frequently used it to formulate cognitive learning outcomes because learning in the affective and psychomotor domains are more difficult to be classified by this framework. Fink (2003) devised an alternative taxonomy to address other important kinds of learning so that students can see the significance of education to their lives and careers. These learning domains also closely resemble the 21st century learning skills that students should acquire before graduating. It comprises six major learning domains: Foundational knowledge which is crucial for other kinds of learning; Application or the use of knowledge for practical action and skill development; Integration to allow for connections between ideas, and perspectives between different disciplinary perspectives or communities; Human dimension that makes a student understands himself, and about others; Caring that enables a change in interest, attitude and values towards learning; and Learning how to learn that produces an autonomous learner who can construct knowledge through self- inquiry. Fink believes that learning will be significant if courses are designed according to his integrated framework.

The circular structure of Fink's taxonomy illustrates that learning is interactive and synergistic (Fig.1). Whenever learning is achieved in any one of the categories, then the ability for achievement is also enhanced in other categories eg when a student "cares" about learning, he would be motivated to inquire for more knowledge (learning how to learn) and in the process begins to make connections of ideas (integration) and with others.

3.1 Application of Fink's Integrated Framework in Higher Education

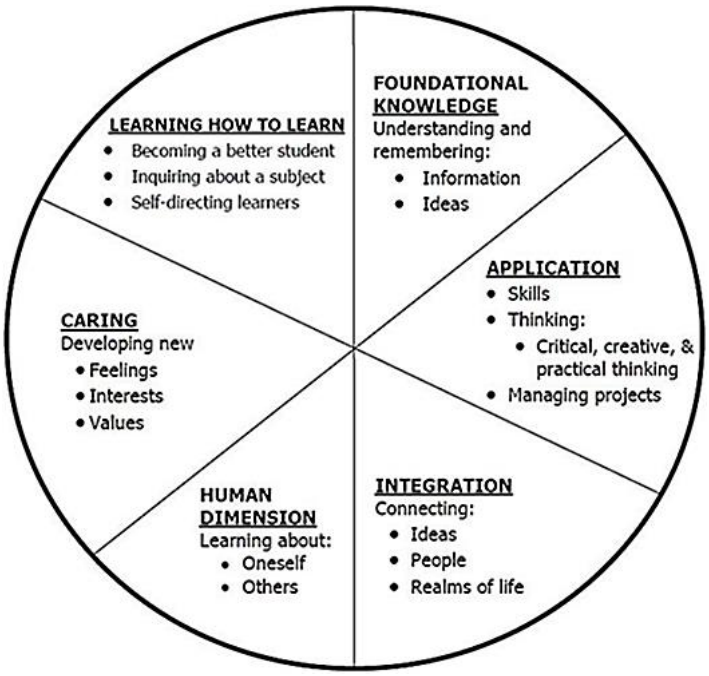

Figure 1: Fink's (2003) Taxonomy of Significant Learning

Faculties who adopted Fink's framework to formulate course objectives, design learning activities and assessment tools have found that students generally were more energized and

learning became long-lasting. (Marrocco, 2014; Guttikonda and Coco, 2013; Ferro, 2011; Krueger *et al*, 2011). Levine and five other instructors (2008) redesigned six courses in different disciplines by alternating lectures and discussions with problem based learning (PBL) that focused on actual situations. Their meta-analysis of student learning outcomes showed significant improvements in the foundational knowledge, application, human dimension and learning to learn domains. Similarly, Fallahi (2008) found undergraduates in a redesigned course in psychology, using Fink's taxonomy and PBL, improved significantly in the knowledge, application, integration and human dimensions compared to those taught in the traditional lecture format.

Methodology

An action research methodology was adopted, with an exploratory and qualitative data analysis. The ensuing sections furnish details on how the project was designed with a review of the situational factors, establishment of learning goals, teaching and learning activities and assessment procedures. The conceptual underpinnings of authentic practice were discussed for each task that students had to do to support the assessment procedures.

Situational Factors

Both Accounting (ACCT 202) and Fundamentals of Human Nutrition (NUTR 201) are second division courses in an American Degree Transfer Program to meet the general education requirements for credit transfer to North American universities. NUTR 201 is offered as an elective to students from a variety of intended majors including nutrition, applied science as well as non-science disciplines. The students may either enrolled in one or both the nutrition and accounting classes in a semester, while others may have enrolled in either one in a previous semester. ACCT 202 is the second core course in accounting for those who intend to major in business. Altogether 24 students in NUTR 201 and 28 students in ACCT 202 participated in this project. Since the students in this study were in their second or third semester, and were not yet ready for industrial internship, this project provided the opportunity for an insightful experience of what to expect in their working lives. To scaffold their learning, each of us continued to lecture in a 60-minute class that met three times a week to provide the prior knowledge of the underlying principles.

The pedagogical challenge here is to make students understand and participate in the integration of accounting and nutritional perspectives for the production of food. Hence the concepts identified to be relevant to food manufacturing include: diet planning, food composition and energy, manufacturing costing and budgeting, and cost-volume-profit analysis. The project was introduced to the classes after the identified topics are completed during the lecture periods, which is around the sixth week in a 14-week semester.

Learning Goals

The project was designed with the principal goals for students to apply their knowledge on top of developing competencies that would be meaningful in their professional lives, such as personal development (effective collaboration, decision making, caring, lifelong learning), entrepreneurial skills (strategic and creative perspectives) and professional standards, all of which are also covered in Fink's learning domains. Because Fink's taxonomy is interactive, he suggested that the learning goals should include as many kinds of significant learning as possible, rather than a few, so that each kind of learning can happen more fully. Therefore, expected learning goals specific to this project were conceptualized with the "ideal graduate" in mind, i.e., someone who would be able to achieve all the six kinds of learning domains in Fink's taxonomy as indicated below:

Foundational Knowledge	Understand the concepts in Nutrition and Accounting that are related to food manufacturing.
Application	Adapt and use the foundational concepts to create a healthy food so as to earn profit, employ practical decision-making skills, solve problems using nutritional and accounting knowledge.
Integration	Synthesize nutritional & accounting perspectives, and related professional standards.
Human Dimension	Work and communicate effectively with others in interdisciplinary team environments.
Caring	Demonstrate awareness of cultural, global and nutritive needs of various groups of people.
Learning how to Learn	Able to independently use a repertoire of knowledge and judgement to negotiate any complex tasks encountered when producing food.

Teaching and Learning Activities – The Project

The project named, "Healthy Version", required students from both courses to collaborate in small teams of four (two from each course) to select and change an existing food into a healthier version. The food must not contain certain types of meat to safeguard religious taboos. They were to cook and sell the food at a profit as motivation to produce healthy and tasty food. Selling food introduced the "fun and competitive" components into the project, besides replicating an authentic practice of food manufacturing from conception, production and sale. Edelson and Reiser (2006) proposed that authentic practice must make the implicit elements explicit so that they can be examined, and mastered. Thus the design discussion in the following sections will focus on identifying authentic learning activities that will address implicit elements that were frequently misunderstood.

NUTR 201

A key feature of manufactured food is the food label with a mandated nutrition fact panel. The nutrition fact label contains detailed information per serving size of the total energy content, and the % daily values mainly for carbohydrate, fat and lipid (macronutrients) for easy comparison with similar foods. This information is easily internalized by professionals, but students are often confused with the concept of food composition, daily values (%DV) and serving size. Food is a composition of several nutrients and the daily value is not synonymous with the recommended daily allowance (RDA), but a portion of it. Most importantly, students must understand that serving size is not equal to the amount of food eaten at one time. Learning activities that will make these concepts explicit involved weighing each ingredient and the macronutrient composition referenced from the textbooks for the corresponding energy to be calculated according to the weight, then apportioned according to the serving and finally calculating % DV by comparison with the RDAs (See Appendices A & B).

The project also called for each team to use healthy ingredients with evidence of nutritive improvement and a food label design that must be displayed together with their food on the

day of sale. The use of healthy ingredients is an authentic practice because it advanced learning to connections with their daily lives regarding food and health. There is no format for the food label design, but it must show the actual image of food that they cooked to avoid plagiarizing images from the internet. The design introduced a creativity component to this project and also made explicit two professional standards regarding food labels. The first standard is the United States Food and Drug Administration (USFDA) mandatory requirements in food labels for manufactured foods. The second is the United States Department of Agriculture (USDA) approved nutrient claims with words such as "free", "high" and "low". Students and consumers are often unaware of the implications that these words must be supported by nutrient contents that are zero gram, >25% DV or < 25% DV of that nutrient respectively.

ACCT 201

Within Accounting, implicit elements relate to identifying direct and indirect costs, costing manufacturing overhead, cost-volume-profit margin and variance analysis. Direct material and direct labor costs are traceable to the products being manufactured. The authentic activities required students to keep track of materials purchased and the time spent in preparing and cooking the food as authentic activity. But to maintain profit margin and nutritive quality, the accounting students must also integrate with the nutrition students to arrive at the most suitable ingredients. The indirect cost in this project was concerned only with manufacturing overhead. Overheads involve a wide variety of items which cannot be traced to the product and are typically complicated and unfamiliar to non-professionals. As a course project, the cognitive complexity was simplified by defining overheads as gas and water apportioned as a percentage of direct materials (See Appendix C). In addition to cost analysis, students were given opportunities to develop "business sense" by applying a 25% mark-up to the selling price. Variance analysis, the quantitative investigation of the difference between actual and planned cost, is another authentic practice which explicitly highlight how manufacturing cost control is dependent on market forces and human behavior (See Appendix D), and the relationship between direct materials usage (efficiency) with pricing (purchase price), and direct labor efficiency with wage rate.

Assessment

Two types of assessment were used for this project - group reports, a food label design and an individual reflective essay, to make the learning outcomes more visible. To ensure consistency for all groups, the group report templates shown in Appendices 1 to 4 were made available to students. The design allowed time for repeated reviews to clarify and revise their calculations when necessarily, so all these reports including the food label design were tools for formative assessment. Verbal feedbacks were given by the instructors and other students during an oral presentation of their planned food two weeks after the project was introduced. These feedbacks provided opportunities for the teams to reflect on their own work and to draw inspiration from others. Team members also evaluated each other for effort and contribution, but peer evaluation will not be discussed in this paper.

Reflection is a metacognitive practice and a potent way for fostering self-awareness (Zubizaretta, 2003). It is also authentic practice as it makes students review the experience from other perspectives. Reflection is therefore a good tool to use for assessing perceived learning outcomes arising from the completion of this project. One week after the food sale, we required each student to submit an essay to reflect on how this project had impacted their learning. There was no specific required format for the essay, but they were told to be candid in narrating their learning experiences, and to include course contents in their reflections whenever possible. Thematic analysis of students' reflections relied on suggestions by Barnes and Caprino (2016).

Both of us read the reflections individually and identified significant words/ phrases / statements via the various coding levels. We sorted the codes into themes in relation to the learning categories in Fink's (2003) taxonomy. Descriptive statistics were used to represent the data.

Results and Discussions

Evaluations of the food labels evidenced concept applications that extend to other areas of their lives. This could be seen in the various ways that the teams have made a normal food healthier (Table 1). The creations demonstrated that students have understood what is meant by healthy ingredients that can lead to remarkable changes in the nutritive content of the food. Their foods also indicated knowledge of nutrient functions and awareness of the current shift in global trend towards consumption of high energy, sugar and salt, but low fiber food (Kearney, 2010). Their endeavors, as food manufacturers, paid attention to creating foods that were contrary to the global trend consumption ie, foods that had less calories, fat, salt and sugar but higher fiber. Effective but inexpensive alternative choice of ingredients was shown by the use of smooth tofu for high fat cream in the chocolate pot; black beans for high fat cocoa powder, cauliflower for pizza crust, bananas and dates for sugar and aquafaba for eggs. These creations allowed for making profit, along with manufacturing (with care) for the special needs market such as those with lactose and gluten intolerances, diabetics and vegans.

Table 1: The Various Healthy Version Creations by Students

Type of Food	Main Ingredients (Healthy Version)	Main Ingredients (Original)	Healthier Nutrition Fact Per Serving	Original Nutrition Fact Per Serving
Bibimbap (Korean mixed rice)	Oats Canola oil	White rice	1 bowl (100g) Fat 7g Fiber 10g	1 cup (100g) Fat 10 g Fiber 4g
Chocolate pot	Smooth tofu	Cream	4 pots (100 g) Fat- 8g Cholesterol - 0 mg Protein – 6g Calories- 164	4 pots (100 g) Fat -24.5g Cholesterol - 176 mg Protein- 4g Calories - 352
Brownies	Black bean, Flourless	Cocoa, Wheat flour	1piece (30g) Gluten free Fiber 6g Brown sugar 7.5g	1 piece (30g) - Fiber 0.6g Sugar 11g
Non-dairy ice-cream	Banana, Soymilk, Sugar free	Milk, Sugar	100g Lactose free Fat – 0g Fiber – 2.6 g Sugar - 0g Calories - 90	100g - Fat – 10g Fiber – 0.7 g Sugar - 22 g Calories – 200
Vegetable Pizza	Cauliflower crust	Wheat flour	1/4 piece (100g) Gluten free Carbohydrate 17g Sodium 185mg	1/4 piece (100g) - Carbohydrate 36 g Sodium 480 mg

Vege Pancake	Soy Milk Gluten-free flour Aquafaba Bananas & dates Olive oil	Milk Wheat flour Egg Sugar Butter	1 piece (80g) Total fat – 1g Calories - 90	1 piece (80g) Total fat – 5g Calories - 140

An original food label created by one team is shown in Fig. 2. The label displayed all the mandatory information required by USFDA. These include the identity of the food, the nutrition fact panel, the name and address of manufacturer, and the net weight. The use of tofu with zero gram cholesterol to replace dairy cream justified the nutrient claim according to USDA.

Fig. 2: A Student's Food Label Design

Meanwhile accounting students were able to think as food manufacturers by applying practical thinking and problem solving skills in several authentic instances below which were validated by their reflections.

i) Planning a budget was found to be challenging as wastage could arise from mismatch of purchase with actual usage. JH commented that "*Some of the ingredients were used in such small amounts that it was impossible to determine the cost, while they can only be purchased in large quantities. This resulted in unfavorable direct material variances and a lot of wastage during the cooking trials*".

ii) Strategic thinking and application of economies of scale concept, was clear from the final decision taken by JH's team "*to take the risk to use all the ingredients by cooking a larger portion, and we actually made a little profit from the sale*".

iii) Practical problem solving relating to cost-volume-profit analysis was demonstrated by Q's team: "…*because sale of our pancake was not good, we decided to sell them*

at RM1.50 per piece instead of the budgeted selling price of RM 2.00 to clear all our stocks".

iv) The relationship of cost control and human behavior was evident in A's team where "*Student #1 was given a higher budgeted direct labor cost since he was tasked to fry the pancake during the day of sale. However his actual labor cost became similar to the others because he did less than expected and eventually everyone had a hand in the frying*".

v) Extending decision making by CO's team to embrace entrepreneurial skills and marketing strategies: "*Initially we planned to sell mac and cheese, but after the trial cooking we didn't think it would sell well. So we changed our food, but the initial costs had to be borne by all of us. In order to cover the sunk costs, we upped our profit margin with a higher selling price. Because the size of the cookies turned out to be rather small, we flattened the cookie to make them appear bigger and price worthy. We also used an attractive wrapper*".

Working together in an interdisciplinary environment however can be both rewarding and challenging. Student E liked the idea of working with others from a different course as it made her appreciate "*the diversity of different disciplinary opinions which can actually complement each other to build a positive working environment*".

In contrast JY, a nutrition student, was disappointed with her accounting teammates because "*In essence we worked as two separate units - one to deal with the purchasing and cooking, the other to deal with the costing and budgeting. The nutrition course students even had to bring the cooking utensils on the day of sale. All the accounting students did was to stand around during the sale of food*". JY's comments showed that interdisciplinary integration may not always transpire because each discipline can become possessive of its own perspectives, as observed by Mansilla and Doraisingh (2007). This will result in the team working as two separate units. Nevertheless it should also be noted that interpersonal conflicts do not only arise across disciplines, but are common in any form of group work due to different work ethics, logistic issues and variable individual commitment that could result in social loafing.

However it should be noted that interpersonal conflicts do not only arise across disciplines, but are common in any form of group work due to different work ethics, logistic issues and variable individual commitment that could result in social loafing.

Mapping students' reflections to the learning outcome categories of Fink's taxonomy revealed that the most frequently reported outcomes were in the areas of human dimension, application and integration (Table 2). The human dimension was obviously easily achieved in group work.

Participation had improved their interpersonal skills such as communication and working with others as well as revealing their own weaknesses and strengths, increasing self-esteem, ability to manage time and ability to resolve social conflicts. Application of foundational concepts including quantitative skill development was the next frequently reported learning outcome and was also explicit in the various submitted reports. Fink (2003) considered integration as making connections between ideas, realms of life (between school and work) and different disciplines. Consideration of interdisciplinary perspectives in the selection and preparation of the food along with connecting their food to the consumers and global trends in this project

were indicators of the development of the type of intellectual thinking expected in the workplace.

Table 2: Major Statement Codes Relevant to Thematic Analysis of Students' Reflections

Statement Codes	Fink's Learning Domain	% Reflections
Know/learn about myself and about others (feeling, work ethics, self-esteem, group dynamics)	Human Dimension	39
Calculate, use information, to create, management of project, problem solving, finding solution, make decisions, skills development	Application	30
Incorporate/connect/ relate ideas, insights from other people, disciplines	Integration	16
Research, information retrieval, self-inquiry,	Learning to Learn	6
Understand, remember, content knowledge	Foundational knowledge	6
Develop new personal interest, values, feelings about an issue, a topic, change perspective	Caring	3

The other domains were not easy to evaluate as they were not directly visible. These were mainly implied from students' reflections about literature research and information retrieval for learning to learn, while perception of caring was discerned from the reported thoughtful attitudinal change regarding learning. For instance, CO cared more about learning now by a change of attitude which he conceived as "having the initiative, responsibility and the keenness to learn". Although this project was not designed to deliver foundational knowledge, it had helped to reinforce the understanding of the more difficult concepts as alluded by N who found the experience beneficial because "it helped me grasp the abstract topics more clearly".

Conclusion

This project made students work in disparate disciplines to challenge them with complex, real-world activities in food manufacturing. While they were enriched by the experience, there were also some challenges. Some students had variable commitments because of divergent academic goals and were less prepared to interact with each other. In the future, both instructors need to encourage students in both courses to have more face-to-face meetings instead of relying on technology for communication. Some groups struggled more than others in the calculations. This is relevant to authentic learning which gets them out of their comfort zone to confront uncertainties.

Although the results of this work is limited to one semester, it had added value to the learning of accounting and nutrition by enabling better understanding of concepts that are difficult to grasp, and creating an opportunity for the connection of learning with the profession in a fun and low risk environment. The experience also trains students to become flexible and adaptable when they encountered problems or when they work with others within and outside their disciplines. These skills would be beneficial for individual success in the work place where networking and multifaceted perspectives are needed.

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Appendix A: Template for Nutrition facts

Original Version	Healthy Version
Main Ingredients ➢ ➢	Main Ingredients ➢ ➢
NUTRITION FACTS Serving Size Amount per Serving CALORIES: % DV Total Fat (g) Cholesterol Total Carbohydrate: Dietary fiber (g) Total sugar (g) Protein (g) Sodium (mg)	**NUTRITION FACTS** Serving Size Amount per Serving CALORIES: % DV Total Fat (g) Cholesterol Total Carbohydrate: Dietary fiber (g) Total sugar (g) Protein (g) Sodium (mg)

Appendix B: Template for Food Composition and Energy Content

Ingredients	Weight (g)	Carbohydrate (g)	Protein (g)	Fat (g)	Fiber (g)	Sodium (mg in salt)	Energy (Kcal)
Total weight							
% Daily Value							

Appendix C: Template for the Budget

Direct Materials (Ingredients per serving)	**Budgeted Price /serving (RM)**	**Total Budgeted cost for no. of servings (RM)**	**Actual cost /serving (RM)**	**Total Actual Cost for no. of servings (RM)**
Total Direct Material cost				
Direct Labor	**RM/hr**	**For *x* hrs**	**RM/hr**	**For *x* hrs**
Student #1				
Student #2				
Student #3				
Student #4				

Total Direct Labor cost			
Overheads	**@ 6% of Direct Material Cost**		**@ 6% of Direct Material Cost**
Gas & water			
Total Cost			
25% Mark-up on Cost			
Targeted Sales Revenue			
Budgeted Selling Price per serving		Actual Cost per serving	

Appendix D: Template for Variance Analysis

	Budgeted cost/unit (RM)	**Actual cost /unit (RM)**	**Variance (RM)**	**Variance Status (F/UF)**
Direct materials (Ingredients)				
Direct Labor				
Student #1/hr				
Student #2/hr				
Student #3/hr				
Student #4/hr				
Total Direct Labor cost				
Overhead				
Total estimated overheads				
Actual Sales Revenue for *x* servings @ RM				
Total Cost for *x* servings				
Net Profit (RM)				