

Outcomes-Based Curriculum Model for Bachelor of Science in Mathematics

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Abstract

This study analyzed the existing Bachelor of Science in Mathematics Curriculum of the Bukidnon State University. The analysis started with the review followed by the proposed revision considering the internal and external factors. Internal factors included the level of difficulty, teachers, and facilities. The external factors considered the employability of the graduates, salary, and upward mobility in the position. It formulated three possible curricula with ascending variations from the existing one. Using the Total Probability Theorem (TPT), it came up with a model considered to be the most feasible curriculum of Bachelor of Science in Mathematics. Developing a Curriculum (DACUM) and Outcomes-Based Education framework were used to revise the existing curriculum.

Keywords and phrases: Outcomes-based, curriculum model, BS Mathematics Curriculum, DACUM, graduates

Introduction

The goal of the Bachelor of Science in Mathematics (BSM) program is to prepare graduates to pursue higher studies or to work in a variety of fields (CMO 19, s. 2007). As such, every institution offering the program holds the responsibility of responding to this challenge. Concomitant to this goal is to equip students with the essential tools to land a decent employment after graduation. This situation made the Commission on Higher Education (CHED) commit to developing competency-based learning standards to achieve quality education through Outcome-Based Education (OBE).

OBE is an approach to education that

identifies its intended product which is the students' competencies by determining the curriculum outcome. The predetermined outcome is used to plan the curriculum, monitor and evaluate its implementation, and assess students' achievement. It can be said that OBE emphasizes what is expected from the students to achieve when they complete their course. Decisions about the curriculum depend on students' outcomes like professional knowledge, skills, abilities, values and attitudes which are determinants of employment.

Getting employment after graduation is not easy for most of the graduates (Pavlin, 2013). Yorke and Knight (2003) defined employability

as a set of achievements, skills, understanding and personal attributes that make graduates more likely to gain employment and be successful in their chosen occupation. This could benefit not only themselves, but also the work force, the community and the economy. It implies the possession of competencies and qualities that are required to enable graduates to enter and maintain employment throughout their lives. According to Boholano (2012), it is through quality education coming from a good curriculum coupled with proper training that one may get a respectable job after graduation.

In the current trend of education, as mandated by CHED, universities and colleges use the employment of their graduates to evaluate how their program performs in making their students productive in the job market. It is used as a performance indicator for college education institutions (Smith et al., 2000 as cited by Boholano, 2012; Bruwer, 1998). If a graduate comes from a reputable institution, he or she finds a job faster (Kong, 2011). Otherwise, the graduates will end either unemployed or underemployed.

It is very clear that unemployment or underemployment is equivalent to some inefficiency of their preparations (Bruwer, 1998). Unemployment means poor educational qualification (Peacock, 2007) implying poor education and training (Hick, 2003; Psacharopoulos, 2004), inefficient delivery of basic services, unfavorable learning environment, and may be lack of facilities. The Bureau of Labor and Employment Statistics for 2009-2010 showed almost the same reasons for unemployment of college graduates, as lack of competence, experience, and achievements.

As emphasized by Kinash (2015), one of the strategies to produce superior graduate outcomes for them to get employment aligned to their fields of specialization is to have concerted effort and collaboration between the university and the prospective employers from the industries. She added that there is evidence of gaps between the perspectives

of students on the competencies required in the workplace if experts from the industries are not involved. Furthermore, to enhance graduate employability, there is a need to explicitly articulate the relevant skills in the learning outcomes for every subject. Hochstein & Hochstein (2000) reported that DACUM is one of the major sources of industrial input to modify the curriculum. They found that it is an effective method of identifying the competencies, skills, and attributes of employees in an occupation.

The context of BS Math graduates employment has to be considered as well in the concept of employability. In the study of Laraya (2009) on the employability of graduates, findings revealed that Bachelor of Science in Mathematics is the least sought after course by employers. Similarly, in the survey conducted to the new BS Math graduates whether they had a specific career in mind, out of the 296 responses, 197 (67%) answered "no". Though at this stage in their education, this need not cause concern and in fact one of the attractions of studying a mathematics degree is that it leaves career options fairly open. However, the results highlight the fact that students need effective support and guidance throughout their program to help them find rewarding and interesting careers when they graduate.

One of the main messages to convey is that when it comes to career planning, it pays to prepare a curriculum that equips the students for the necessary options in the field of work after graduation. With the implementation of K-12, private and public schools which need to increase their teachers, math graduates have greater chances of being employed. However, the minimum entry requirement to teach senior high school is with masters units, thus BSM graduates still have to enroll for a master's degree.

It is for these reasons that the researchers conceived of this study to analyze the existing Bachelor of Science in Mathematics curriculum offered by Bukidnon State University. Though

the program is mandated by CHED through CMO 19, s. 2007 and updated by Balmaceda (2015), the mandate sets only the minimum requirement for the program. Institutions are encouraged to enhance the program based on the needs of the community. The undertaking has a task of analyzing the curriculum to have the most feasible curriculum model for the BSM that addresses the employability needs of its graduates, to help the university attract and retain high quality students, and maintain its competitive advantage in the regional, national and global market place.

The concept of total probability theory was used to find the probability where students chose the proposed curriculum. This is the appropriate rule for relating marginal probabilities to conditional probabilities expressing the choice of the students as total probability of an outcome realized via several distinct events.

The conduct of the study was guided by the following objectives: to build a curriculum model considering the internal and external factors contributory to the number of enrollees in the BS Math Program; to use the Total Probability Theorem (TPT) for the computation of the probability of the curriculum choice of the students; and to use DACUM and OBE to revise the curriculum.

Model Building

In this paper, the Bachelor of Science in Mathematics Curriculum is categorized into four, namely: Curricula A, B, C and D. It is assumed that the number of enrollees in the program depends on the internal and external factors. Internal factors include the level of difficulty of the program, teachers and facilities for the program. The external factors refer to the job prospects, salary of a BS Mathematics Graduate and upward mobility. Further, the BS Mathematics program can be defined in terms of the following factors: content of the program, cost for a student to complete the program and the length of the training of the

program. Each curriculum can be defined by these three factors. Curriculum A is the current curriculum of BS Mathematics used (Status Quo), while Curricula B, C and D differ at different degrees of the three factors. Table 1 shows the variability of the different curricula considering the different factors:

Table 1. Variability of the Different Curricula

Curriculum	A	B	C	D
Factors				
Content of the program	X	X + a%	X + b%	X + c%
Cost for a student to complete the program	Y	dY	eY	fY
Length of the training of the program	Z	Z + g	Z + h	Z + i

Where,

- a, b and c = percentage to be modified in the content of the program
- d, e and f = cost added for a student to complete the program
- g, h and i = additional length of training for a student to complete a program
- X = Content of the BS Math Curriculum (Status Quo)
- Y = Cost for a student to complete the program in BS Math Curriculum (Status Quo)
- Z = Length of training of the BS Math Curriculum (Status Quo)

Computation of Probabilities

In computing the probability where a student chooses to enroll in a certain curriculum, the Total Probability Theorem (TPT) is used. The TPT is given as follows:

Total Probability Theorem

Given n mutually exclusive events whose probabilities sum to unity, then

$$P(B) = P(B | A_1) \cdot P(A_1) + \dots + P(B | A_n) \cdot P(A_n)$$

where B is an arbitrary event, and is the conditional probability of B assuming. The theorem is further presented in Figure 1.

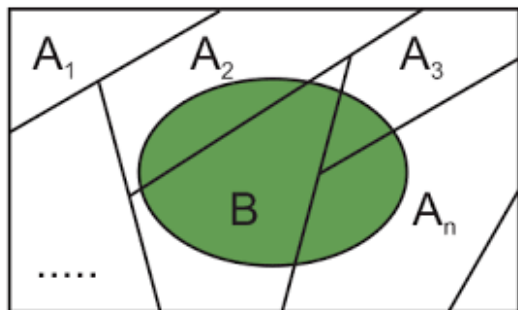


Figure 1. The Total Probability Theorem.

Then, let

- A = be the event that a student will enroll in Curriculum A (Status Quo)
- B = be the event that a student will enroll in Curriculum B
- C = be the event that a student will enroll in Curriculum C
- D = be the event that a student will enroll in Curriculum D
- F1 = content of a curriculum
- F2 = cost for a student to complete the program
- F3 = length of training of the program

Based on the TPT, the probabilities of events A, B, C and D are given as follows:

$$\begin{aligned}
 P(A) &= P(A/F1) \cdot P(F1) + P(A/F2) \cdot P(F2) + P(A/F3) \cdot P(F3) \\
 P(B) &= P(B/F1) \cdot P(F1) + P(B/F2) \cdot P(F2) + P(B/F3) \cdot P(F3) \\
 P(C) &= P(C/F1) \cdot P(F1) + P(C/F2) \cdot P(F2) + P(C/F3) \cdot P(F3) \\
 P(D) &= P(D/F1) \cdot P(F1) + P(D/F2) \cdot P(F2) + P(D/F3) \cdot P(F3)
 \end{aligned}$$

For instance, the probability that a student will enroll in Curriculum A is the sum of the conditional probabilities given the three factors and so on.

Model Appreciation

To appreciate the model, Table 2 is given where values are assigned. This is shown below:

Table 2. Variability of the Different Curricula

Curriculum	A	B	C	D
Factors				
Content of the program (F ₁)	100%	110%	120%	130%
Cost for a student to complete the program (F ₂)	Y	Y+1.5	Y+2	Y+2.5
Length of the training of the program (F ₃)	Z	Z + 0.5	Z + 1.0	Z + 1.50

Where,

- X = Content of the BS Math Curriculum (Status Quo)
- Y = Cost for a student to complete the program in BS Math Curriculum (Status Quo)
- Z = Length of training of the BS Math Curriculum (Status Quo)

The computed probabilities are the following:

$$P(A) = 0.06$$

$$\begin{aligned}
 P(B) &= (1.5) \cdot P(A) \cdot (0.058) + (0.5) \cdot P(A) \cdot (0.2231) + P(A) \cdot (1) \\
 &= P(A)[(1.5)(0.058) + (0.5)(0.2231) + 1] \\
 &= (0.06)(1.19855) \\
 &= 0.071913
 \end{aligned}$$

$$\begin{aligned}
 P(C) &= (1.7) \cdot P(A) \cdot (0.040) + (1) \cdot P(A) \cdot (0.0498) + P(A) \cdot (2) \\
 &= P(A)[(1.7)(0.040) + (1)(0.0498) + 2] \\
 &= (0.06)(2.1178) \\
 &= 0.127068
 \end{aligned}$$

$$\begin{aligned}
 P(D) &= (1.9) \cdot P(A) \cdot (0.027) + (1.5) \cdot P(A) \cdot (0.0111) + P(A) \cdot (3) \\
 &= P(A)[(1.9)(0.027) + (1.5)(0.0111) + 3] \\
 &= (0.06)(3.06795) \\
 &= 0.1841
 \end{aligned}$$

Table 3 presents the summary of the probabilities (i.e., proportional, cumulative and interval).

Table 3. Summary of Probabilities

Probabilities	Proportional Probabilities	Cumulative Probabilities	Probability Interval
P(A) = 0.0600	0.1354	0.1354	0 ≤ P(A) ≤ 0.1354
P(B) = 0.0719	0.1623	0.2977	0.1354 < P(B) ≤ 0.2977
P(C) = 0.1271	0.2868	0.5845	0.2977 < P(C) ≤ 0.5845
P(D) = 0.1841	0.4155	1.0000	0.5845 < P(D) ≤ 1.0

To use the probability interval, 2,000 random numbers are generated representing the number of first year students of the College of Arts and Sciences of Bukidnon State University for School Year 2015-2016 using Uniform Distribution. Random numbers are tallied based from the probability interval given. For example, a random number of 0.2516 belongs to the interval. This means that this student will enroll in Curriculum B. In summary, the final results of the 5056 students who will enroll in a specific curriculum are:

P(A) = 14.00% (N = 280)

P(B) = 15.60% (N = 312)

P(C) = 28.05% (N = 561)

P(D) = 42.35% (N = 847)

Discussion

Based on the simulation done, results showed that almost half of the first year students will choose Curriculum D. Factors involved are the content of the program, cost for a student to complete the program and the length of training of the program. To be specific, the assumption that the content of the present program be modified at some percentage is a challenge. The question on how much of the current curriculum is modified to be attractive to students and at the same time addresses the needs of an outcomes-based curriculum (i.e., a paradigm-shift to a learner-centered), revision was done with the use of Developing A Curriculum (DACUM).

DACUM is a job occupational analysis performed with expert workers in the occupation. Its philosophy is that expert workers can describe and define their jobs more accurately than anyone else (Padua, 2012). It observed the nine-step process of the development, namely needs analysis, job/occupational analysis, task verification, task selection, task analysis, competency profile, curriculum materials, training, and competency and program assessment. However, in this study it only included the needs analysis, job/occupational analysis, and task verification as the concern of the study is only on curriculum preparation. It begins with the needs analysis also called needs assessment.

The goal of needs analysis is to identify which occupational areas have enough employment opportunities and will attract enough students to justify an instructional program. Several factors can enter into this analysis, such as salary levels and required skill levels in the occupation. Exploring career options involves researching occupations and industry sectors that fit the skills,

interests, personality preferences and values of the graduates. An occupation relates to the activities of the work to be performed, whereas industry sector classifies the organizations that employ people in such occupations. Mathematics graduates have the skills to apply quantitative knowledge and reasoning, define a research problem, design/use computer simulations, develop mathematical models and theories, establish and control hypothesis designs, gather, analyze and interpret data, identify relationships among factors, perform statistical analysis, prepare technical reports and review scientific literature (Padua, 2012). Additionally, he mentioned some of the following occupational titles for Mathematics graduates: Financial Manager, Real Estate Developer, Chartered Accountant/Financial Auditor, Financial/Investment Analyst, Financial Accounting Supervisor, Accounting Technician, Account Manager/Mortgage Consultant, Research Scientist, Mathematician/Actuary, Computer Systems Analyst, Computer Programmer, Teacher/Professor, Mathematical Economist, Risk Management Analyst, Market Researcher, Public Policy Analyst, and Senior High School Teacher. After determining the possible jobs/occupations of the graduates, the next component of the curriculum development process is job/occupational analysis.

Job/occupational analysis is a systematic process in which individuals make judgments and collect data to document the requirements of a job and the work performed (Brannick & Levine, 2002). It provides a detailed description of particular duties, responsibilities, necessary skills, requirements, and the work environment (Morganson, Major & Bauer, 2009). It involves finding out what should be taught to students. Here, with the expert workers in the identified occupation as guide, duties and tasks or competencies were identified. The output is the DACUM Research Chart (DRC) for the identified career outcome of the BSM program.

Task verification of the DACUM process, verifies selected aspects of each task identified

in the process. It considered the following guide questions: Is the task actually performed in the job? How important is the task? How difficult is it to learn to perform the task. How frequently is the task performed? These questions were asked from the expert workers and their immediate supervisors. Statistical analysis results form the basis for decisions about which tasks should be taught. This means that task verification does not only provide critical decision-making data, but also creates good public relations. Competency profile was produced that describes comprehensively the duties and tasks of BSM graduates. This information is necessary because of a desire to design a BSM curriculum to be as prescriptive as possible to reduce the gap between what is actually performed in the occupation and what is taught in the classroom.

OBE Features of the Revised BS Math Curriculum

The OBE features in the revised BS Math curriculum are manifested in the subjects included on top of the minimum requirement set by CHED as indicated in CMO 19, s. 2007 and updated by Balmaceda (2015) in the unnumbered CMO, s. 2015. The subjects included were based on the results of the DACUM as recommended by the expert workers in the field of work who defined the needed competencies in the real world.

Conclusion

A curriculum model in Bachelor of Science in Mathematics can be prepared considering the internal factors that included the level of difficulty of the program, the teachers and the facilities; and the external factors like the job prospects or employability, salary and upward mobility. Model was obtained using the Total Probability Theorem. The curriculum was realized using the DACUM process that requires sufficient preliminary research to identify enough information regarding duties and tasks of the job, and the necessary competencies to be developed in students. With these

processes, graduates of the Bachelor of Science in Mathematics would be well equipped with the necessary tools to land a decent job.

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