Bloom's Taxonomy Based Proportionate Curriculum Development Model

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Abstract
This paper presents a research conducted to analyze an undergraduate engineering program curriculum to determine if the cognitive challenges represented by the course learning outcomes were consistent with the level of course and whether the appropriate action verbs were used to write each learning outcome in consistent with Bloom's six cognitive domains. A document analysis research method was employed to conduct this analysis. The learning outcomes for each syllabus of an engineering program were examined and action verbs associated with each domain were counted. Based on this analysis a proportionate range of percentages for each cognitive domain of Bloom's taxonomy for freshman, sophomore, junior and senior level courses of a typical degree program is proposed.
Keywords: HOTs, LOTs, Curriculum progression, Action verbs

1. Introduction

A curriculum is a well-defined and prescribed course of study that serves to provide an insight into learning goals and outcomes, instructional material and activities, and assessment methods and procedures used during the delivery of a program curriculum. The institutions providing higher education must establish a mechanism to develop, analyze, and evaluate their educational programs periodically to determine the quality, relevance and effectiveness of the curricula.

Bloom's taxonomy (Bloom, B.S. et. al. 1984) is the most versatile and well established model for analyzing and assessing the cognitive depth of students' learning and their ability to perform specified tasks envisioned in a curriculum. The model is regarded as a concise model for the analysis of educational outcomes in the cognitive area of remembering, thinking, and problem solving. The original model has been slightly modified by Anderson et al (Anderson, L. W. et. al. 2001). Both original and revised versions of the Bloom's taxonomy are illustrated in Figure 1. The curriculum design and assessment is a necessary exercise for any academic program which is generally based upon the principles of Bloom's taxonomy (Sanders, I. et. al. 2000).

In a degree program, a substantial portion of curriculum is normally taught to cater knowledge, comprehension, and application (first three levels of Bloom's taxonomy generally referred as lower-order thinking skills (LOTS) (King, F. J. et. al. 1998)) through lower division (100 and 200 level) courses.

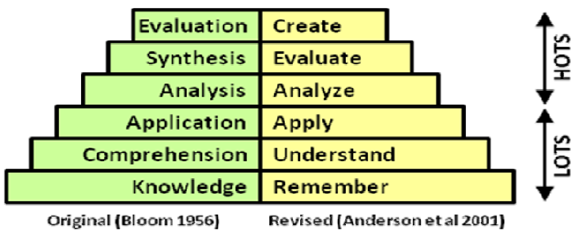

Figure 1. Bloom's taxonomy

In a On the other hand the upper division (300 and 400 level) courses of the curriculum emphasize more on last three levels i.e., analysis, synthesis and evaluation generally referred as higher-order thinking skills (HOTS) (King, F. J. et. al. 1998). The curriculum progression outlining this transition scheme in the context of both original and revised taxonomies is conceptualized in Figure 2.

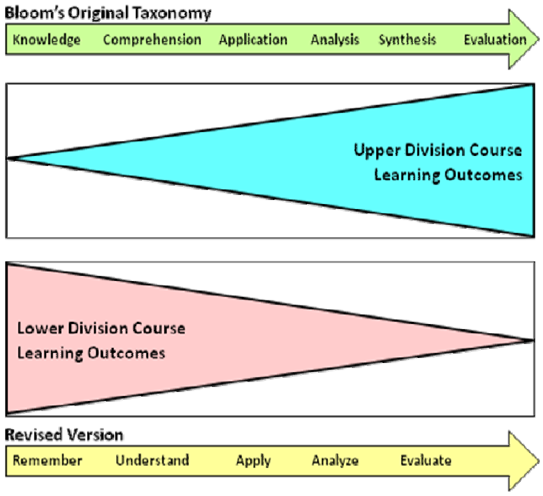

Figure 2. Curriculum progression and Bloom's levels

Though it is difficult to standardize the percentages of cognitive domains in each level of courses, the percentage of lower level Bloom's cognitive domains should be more in lower division courses whereas the percentage of higher level Bloom's cognitive domains should be more in upper division courses of the program curriculum. A reasonable pace of transition from LOTS to HOTS is likely to be conditioned by the perceived abilities of the students at any particular institution.

The program objectives and outcomes stated in a curriculum are linked with the course learning outcomes described in each individual course syllabus of a program. Therefore, assessing the curriculum depends on the assessment of the course learning outcomes. The assessment process allows us to determine whether or not intended learning outcomes of the courses as well as the program are being achieved. The results obtained from this process can be used to improve and enhance the quality of the academic program.

The preceding discussion leads us to believe that the course learning outcomes should be skillfully worded using action verbs that specify definite and observable behaviors. Concrete "action" verbs such as 'define,' 'argue,' or 'evaluate' to specify learning outcomes are more helpful for assessment than "vague" verbs such as 'know,' 'understand,' or "passive" verbs such as 'be exposed to'. (Anderson, L. et. al. 2001) suggested that cognitive dimension process may be grouped into three categories; "C-1" – remembering, recognizing, and recalling i.e. Knowledge, "C-2" – Comprehension, and "C-3" – Apply, Analysis, Evaluate i.e. the higher level of cognitive domains.

A research study (Wesley A. 2013) divided cognitive domain pyramid into three levels of thinking skills and suggests that "knowledge" and "comprehension" should be more emphasized at high school level, "application" and "analysis" should be more focused at undergraduate level, and "synthesis" and "evaluation" should be more concentrated at the graduate level. At the undergraduate level, we can adopt a similar analogy that lower level cognitive domains of the Bloom's pyramid should be largely covered in "100-level" and "200-level" courses, the middle two cognitive domains should be covered in "300-level" courses whereas the skills associated with the two higher cognitive domains should be the focus of the part of the curriculum in "400-level" courses.

Section 2 presents data collection and analysis along with the curriculum details, methodology, and the results of the analysis. A proposed model outlining certain percentages emphasizing Bloom domains for writing course learning outcomes of a degree program curriculum are discussed in section 3. The conclusions of the work are given in section 4.

2. Data Collection and Analysis

The degree program in engineering used for this study consists of 48 courses contributing to 139 credits completed in eight semesters. The credit composition of courses in various categories and course levels is summarized in Table 1.

2.1. Methodology

A survey of the literature available on the Internet was conducted to compile a list of "action" verbs associated with each of the six Bloom's taxonomy domains. This list facilitated the process of designating the learning outcomes in appropriate Bloom domain in a consistent and reliable manner. The document analysis research method was employed to conduct the analysis presented in this paper.

Table 1. Level and category-wise credit composition of the program curriculum

Course Category	**Credits in Level**				**Total Credits**
	100	**200**	**300**	**400**	
Social Sciences and Humanities Courses	30				30
Mathematics and Basic Sciences Courses	08	17			25
Foundation Courses	01	14	24		42
Core Courses				21	21
Elective Courses				15	15
Graduation Project				03	3
Internship			6		6
Total	**39**	**31**	**30**	**39**	**139**

The learning outcomes of each syllabus were examined and action verbs associated with each domain were counted. A tool developed in MS Excel was used to collect and analyze the data. The words/verbs not matching with any of the action verb in the compiled list were discarded. Due to space limitation the complied list of action verbs used is not presented in this paper.

2.2. Results

The analysis of engineering program curriculum using course learning outcomes of its syllabi is given in Table 2. Level-wise summary of results presented in the table shows that for freshman (100 level) courses, the greatest emphasis is on application (33%) domain as compared to knowledge and comprehension (15% each). This is contrary to the expectation that lower level cognitive domains i.e., knowledge and comprehension should have more emphasis at this stage of the curriculum.

Table 2. Action verbs count in the program curriculum

Course Levels	**Knowledge**		**Comprehension**		**Application**		**Analysis**		**Synthesis**		**Evaluation**	
	Count	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
100	11	15	11	15	33	45	12	16	5	7	1	1
200	4	7	7	12	40	70	3	5	3	5	0	0
300	3	6	9	18	29	58	4	8	5	10	0	0
400	0	0	11	22	25	51	1	2	12	24	0	0
All	**18**	**8**	**38**	**17**	**127**	**56**	**20**	**9**	**25**	**11**	**1**	**0**

The higher level Bloom domain percentages i.e. analysis (16%), synthesis (7%), and evaluation (1%) are fairly acceptable.

For 200-level courses, again the percentage of application domain is quite high i.e. 70% as compared to percentages of knowledge (7%) and comprehension (13%). All other domains are also acceptable in this level. The 300-level courses also emphasize on application (58%) whereas the percentages of knowledge (6%) and comprehension (18%) are satisfactory. However, the emphasis on analysis (8%) and evaluation (0%) at this level is not satisfactory. The 400-level courses significantly concentrate on application (51%) and synthesis (24%) whereas the action verb count of learning outcomes emphasizing analysis (2%) and evaluation (0%) domains fail to meet the expected focus at senior level (400-level) courses. The emphasis on knowledge domain (0%) in courses offered at this level is also found to be unsatisfactory. In the degree program as a whole the overall percentages of action verbs relating to the knowledge (8%), comprehension (17%), application (56%), analysis (9%), synthesis (11%), and evaluation (0%) domains do not represent a promising mix of Bloom's taxonomy skills.

It is important to add that the results of the present study are based upon the analysis of written syllabi, i.e., a count of the verbs in the learning outcomes of each course. The engineering curriculum did not show any emphasis on the "evaluation" domain which is a higher level skill domain in the Bloom's taxonomy. Similarly another higher level cognitive skill domain "analysis" also has a little emphasis in upper division courses. In fact, "application" which is an intermediate level skill, has stronger emphases as compared to "synthesis" and "evaluation" which are higher level Bloom skills.

We have not explored the linkage between the learning outcomes and assessment instruments administered throughout the delivery of the course(s). However, we can assume that an appropriate correlation exists and the action verbs count in the course learning outcomes is a reflection of the cognitive skills taught and assessed in the program curriculum.

3. Proposed Model

Based on the analysis presented earlier, we propose a proportionate range of percentages for each cognitive domain of Bloom's taxonomy at freshman, sophomore, junior and senior level courses of a typical degree program. The proposed distribution of lower and higher order thinking skills and the associated learning outcomes of various lower division (100 and 200 level) courses and upper division (300 and 400 level) courses of a degree program curriculum is illustrated in Figure 3. Our proposed model is inspired by two existing models (Theresa H. et. al. 2013, (Woods, J. 2010). Both these models present a trend very similar to our model in the sense that the lower division courses of the curriculum should have a greater emphasis on LOTS and upper division courses of the curriculum should emphasis more on HOTS. The percentages of Bloom's cognitive skills allocated at freshman, sophomore, junior and senior level courses proposed in our model and the two models presented in the references are not exactly same. Considering different nature of constraints and dissimilarities specific to each individual institution, the presence of this difference is quite understandable. The present study would also provide us an opportunity to debate on the above findings at relevant forums in order to generate robust and tangible plans for reviewing the entire curriculum and rewriting the course learning outcomes in the context of Bloom's taxonomy. This would allow us to review and revise the existing program curriculum for placing an appropriate emphasis upon the cognitive challenges consistent with the level of various courses of the program. The analysis presented in this study has also instituted an effective and structured dialogue about the learning outcomes and how to meet the cognitive challenges emphasized in the program curriculum.

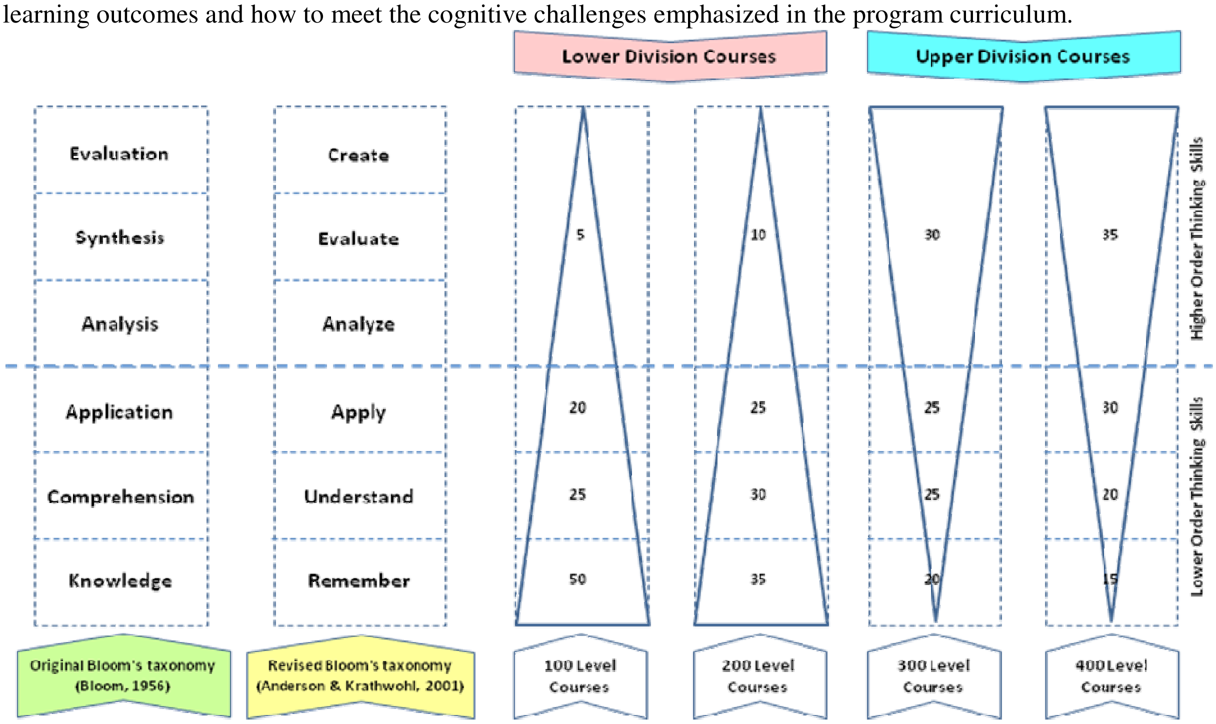

Figure 3. Proposed curriculum progression and Bloom's levels

4. Conclusion

We presented the analysis of curriculum of an engineering degree program in the context of Bloom's taxonomy cognitive domains incorporated in the course syllabi of the program. The results obtained from the study showed that the cognitive domains were not balanced in the program. Based on this analysis, we have proposed a proportionate percentage model for developing and revising any degree program. Our proposed model is being used to revise and review the curriculum of the existing programs being offered at our university. In future, we plan to use text analysis techniques and syllabi databases to develop an automated system that will incorporate our proposed model. This system will enable course planners as well as relevant faculty to develop or revise the course syllabi ensuring that an appropriate mix of Bloom's cognitive domains is maintained in the course as well as in the entire program curriculum by implementing the suggested percentages of cognitive domains in the proposed model.

We also plan to perform a similar analysis of the questions used in the assessment tools used each course of the program to find out the emphasis on the LOTS and HOTS.

5. Acknowledgements

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