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Improving Methods of Measuring Curriculum Alignment

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Abstract: Curriculum alignment studies demonstrate relationships among curriculum, instruction, and assessment (CIA). A well-aligned CIA ensures better opportunities for the students to learn and demonstrate their achievements. Experts have proposed different models for measuring this alignment (e.g., the Web alignment model, Achieve alignment, and the SEC alignment model). However, numerous state agencies have extensively employed the Surveys of Enacted Curriculum (SEC) alignment model for evaluating CIA alignment (e.g., in the USA, 27 states are using SEC tools (CCSSO, 2020)). Conversely, there are two important aspects that have not been considered properly in the SEC alignment measurement method. The first one is the degree of emphasis upon different levels of the cognitive domain, and the other is the difference in the numbers of objectives/items between the two documents. The present paper explores the effect of these important factors upon the measurement of curriculum alignment and suggests possible measures to improve the quantitative measurement of curriculum alignment. In fact, the study would improve the method of curriculum alignment. The improved method would in turn help in improving the quality of instruction and assessment.

Keywords: Assessment; Curriculum; Alignment Measurement; Instruction; Surveys of Enacted Curriculum.

1. Introduction

Standards-based curriculum coupled with a value-added approach in education has necessitated that (a) educational resources be provided according to requirements of the curriculum, (b) classroom instruction is aligned with the curriculum, and (c)the assessment measures the learning outcomes mentioned in the curriculum. Alignment of all components of the education system is essential to achieve the intended outcome proposed in the standard-based curriculum (Contino, 2013, p. 62).

Curriculum alignment studies aim to measure relationships among curriculum, instruction, and assessment (CIA) because a well-aligned CIA ensures better opportunities for the students to learn and demonstrate their achievements (Martone & Sireci, 2009, p. 1333).To find out how much classroom instruction and evaluation is aligned with the curriculum, educationists have proposed different models, including the Web alignment model, Achieve alignment, and Surveys of Enacted Curriculum (SEC)alignment model.

However, curriculum experts from a variety of countries have extensively used the SEC alignment model to determine the level of congruence of instruction and tested curriculum with the curriculum (Woolard, 2007) [e.g., Liu, Zhang, Liang, Fulmer, Kim, & Yuan (2009) in China, USA, & Singapore; Ndlovu & Mji (2012) in South Africa; Kurz, Elliott, Wehby, & Smithson (2010) in the United States for special education; Bhatti The SEC is also important for employing tools which can be commonly used not only for curriculum and assessment but also for instruction and textbooks (Martone & Sireci, 2009).

Porter and his colleagues developed SEC tools and the Alignment Index (AI) formula for quantitative measurement of alignment among curriculum, instruction, and assessment (Porter, 2002). However, Porter (2002) also openly admitted that these tools were not final product but something which may further be improved (p.12). So, many experts continued to work on it and tried to improve the SEC alignment measurement tools. For example, Fulmer's (2011) proposed critical values of AI for measuring how strongly assessments or instruction are aligned with the curriculum.

Similarly, Polikoff and Fulmer (2013) further refined methods to calculate critical values for AI. However, there are two important aspects that have not been considered properly in the SEC alignment measurement method. The first one is the degree of emphasis upon different levels of the cognitive domain, and the other is the difference in the numbers of objectives/items between the two documents.

The present paper explores the effect of these important factors upon the measurement of curriculum alignment and suggests possible measures to improve the quantitative measurement of curriculum alignment. In fact, the study would improve the method of curriculum alignment. The improved method would in turn help in improving the quality of instruction and assessment.

2. Overview of SEC Model

Porter and his colleagues proposed the SEC model, which is also famous as Porter's alignment model (Porter, 2002; Porter& Smithson, 2000, 2001, & 2002). Porter (2002; 2006) advocates that not only the content of classroom instruction but the assessment also have a direct impact upon students' learning. So, SEC consists of tools that employ common linguistic terms for the description of objects to be analysed for measuring alignment (Liu & Fulmer, 2008, p. 375).

Additionally, this language is "systematic and detailed" and it is suitable for the analysis of several curricular materials (Porter & Smithson, 2002). SEC tools contain matrices consisting of rows for topics and columns for the complexity level or depth of the topic expected to be achieved by the students. To reduce the number of rows, one can also cluster similar topics into "content areas". Porter proposed the term "grain size" to describe the level of grouping of topics. Generally, there are two grain sizes, namely the coarse grain level and the fine grain level.

At the coarse grain level, the alignment is measured at a broader level as more topics are grouped into content areas, while at the fine grain level, the alignment is measured at a more detailed level as fewer topics are grouped into content areas (Porter & Smithson, 2002, p.1). Accordingly, the grid has fewer cells while measuring alignment at coarse grain level and has many more cells while measuring alignment at fine grain level. There are two criteria for the measurement of the alignment of every topic, namely (a)the complexity level or depth of the topic and (b) the level of coverage or the time period spent for the instruction of that topic. These levels are formulated in accordance with the curriculum. The below table 1 shows the surveys of enacted curriculum content analysis protocol.

Table 1. Surveys of Enacted Curriculum Content Analysis Protocol

Level of Coverage	**Topic**	**Cognitive Demand**					
Time		Remember	Understand	Apply	Analyze	Evaluate	Synthesize
0 1 2 3	X	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
0 1 2 3	Y	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
0 1 2 3	Z	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3

3. Materials and Methods

A trained panel of experts accurately codes the standards as well as the assessment on the SEC protocol. The instructional content is measured by sending the SEC protocol to the teachers who fill it up according to the instructional content delivered in their classes. As SEC protocols employ common linguistic terms for the description of objects to be analyzed for measuring alignment, each protocol consists of an equal number of rows and columns. After measurement of the content of CIA, a mathematical procedure is adopted to find the alignment (extent of similarity) among CAI. This procedure has two important steps. In the first step, basic data about content emphasis is calculated in each cell of the SEC protocols. This calculation consists of the following two steps:

1. Find the sum of all the values in every cell of matrix obtained by the SEC protocols
2. Divide the values in every cell of matrix obtained by the SEC protocols by the sum of values got in the first step.
3. The sum of basic data obtained through this way is 1.
4. The second step is finding quantitative measure of alignment by calculating alignment index (AI) through this formula:
   a. AI = $1 - \frac{\sum(X-Y)}{2}$
5. In this alignment index formula:
   X = value on one cell of a matrix
   Y= value in corresponding cell of other matrix.

It is important to note that the maximum value of the alignment index may be set to 1, which indicates perfect alignment, and the range minimum value of the alignment index may be set to 0, which indicates perfect misalignment. Fulmer (2011) also worked on the SEC and proposed critical values for the alignment index. By using Fulmer's table of critical values, the strength of alignment can be determined.

4. The Issues

Roach, Niebling & Kurz (2008, p. 164) advocate that the SEC has become a widely used and dominant tool for measuring alignment because of:

1. Employing a framework of common linguistic terms to examine the content,
2. Calculating the level of alignment in the form of single digit, and
3. Having an additional value of presenting the results in the visual form through graphical output.

However, an important issue that has not been considered while analyzing data obtained through SEC protocols is the comparative significance of different levels of cognitive demand. We know that Bloom (1956) categorized the objectives with ascending level of complexity.

The higher-level objectives demand greater time and effort from the teachers as well as the learners. For example, critically analyzing Newton's law of gravitation and remembering its definition neither have the same levels of significance nor can be treated equally. Conversely, lower level (e.g., remember) and higher level (e.g., analysis) objectives have the same weightage in the SEC alignment measurement method.

The situation becomes more critical when we find that the ratio of objectives involving higher levels of intellectual activity in national/state standards is comparatively much less than those of lower levels. For example, 92% objectives of New York Physics Content Standards for physics belong to first three categories of cognitive demand while only 8% belong to last three categories of cognitive demand (Liu, Zhang, Liang, Fulmer, Kim, & Yuan, 2009). Similarly, ratio among the first three cognitive demand levels with the last three cognitive demand levels in New York Content Standards for Earth Science is 94% and 6% (Contino, 2013, p. 65).

Therefore, objectives relating to higher levels of cognitive domain, in spite of having great significance, have no significant role in CIA alignment measurement due to their lower quantity. In fact, instead of giving proper significance to the objectives relating to higher levels, the SEC model underemphasizes these higher-level objectives. It may be owing to this less emphasis upon the higher levels of objectives that Giroux (2010) opposed curriculum alignment by arguing that it curbs critical thinking, self-reflection, and deep involvement. Curriculum alignment tends to make students just accumulators of knowledge (Sleeter, 2005) and not independent thinkers and critical intellectuals (Bauman, 2010; Rubin & Kazanjian, 2011). The instruction aligned with the curriculum can raise students from just being "accumulators of knowledge" to being independent and critical thinkers if we give proper weightage to objectives relating to higher levels of cognitive domain in curriculum alignment.

The second issue is the total number of objectives and scores in CIA. This total number plays a very important role in calculating ratios for finding the Alignment Index. Table 2 shows the impact of the total number of objectives and scores upon the ratio scale. The first row shows the total number of objectives/scores and the first column shows the number of objectives whose ratio scale is to be calculated. The next five columns show the ratio scales with respect to the total number of objectives and scores.

For example, the ratio scales of only the first 8 digits have been calculated. In most of the alignment measurement studies, the AI has been calculated up to two decimal points. So, if the total number of objectives/scores is 200 or 150, different digits have the same ratio scale. For example, if the total number of objectives/scores is 200, digits 1 & 2, 3 & 4, 5& 6, and 7 & 8 have the same ratio scale of 0.01, 0.02, 0.03 and 0.04 respectively. It is clear that the greater the total number of objectives/scores, the lesser the level of differentiation.

Table 2. Impact of total number of objectives/scores upon the ratio scales

Scores	200	150	100	50	20
1	0.01	0.01	0.01	0.02	0.05
2	0.01	0.01	0.02	0.04	0.10
3	0.02	0.02	0.03	0.06	0.15
4	0.02	0.03	0.04	0.08	0.20
5	0.03	0.03	0.05	0.10	0.25
6	0.03	0.04	0.06	0.12	0.30
7	0.04	0.05	0.07	0.14	0.35
8	0.04	0.05	0.08	0.16	0.40

The third issue is the unequal number of objectives or items in the curriculum and the instruction, assessment, or textbooks. Mostly the total number of students learning outcomes in the curriculum varies from the total number of students learning outcomes covered in the textbook or assessment. For example, Liu, ibid. measured the alignment in physics in three education systems of three countries, including China, the United States, and Singapore.

They used the SEC method for measurement of alignment. In this study, they found that there were 100 points for content standards (Table 2) and 85 points for the New York State Regents Physics Exam (Table 2). As the sum of content standards is 100, the ratio represents the placing point after two digits of the number of content standards.

However, for the Regents' exams, as the total of points is 85, while calculating ratios, every number has greater value as compared with the content standards. For example, the ratios of the numbers 3, 10, 19, & 50 in content standards are 0.03, 0.10, 0.19, &0.50 respectively, while the ratios of the same numbers 3, 10, 19, & 50 in Regents' exam are 0.04, 0.12, 0.23, & 0.59 respectively. The details of these differences are shown in Table 3 and Table 4 respectively.

Table 3. New York Physics Content Standards[1]

	Remember		Understand		Apply		Analyze		Evaluate		Create	
	STD[a]	RA[b]	STD	RA	STD	RA	STD	RA	STD	RA	STD	RA
Energy	0	0	8	.08	7	.07	2	.02	0	0	0	0
Motion and Forces	0	0	13	.13	18	.18	1	.01	0	0	0	0
Electricity	0	0	7	.07	7	.07	2	.02	0	0	1	.01
Waves	0	0	11	.11	9	.09	2	.02	0	0	0	0
Properties of matter	0	0	09	.09	3	.03	0	0	0	0	0	0
Subtotal	0	0	48	.48	44	.44	7	.07	0	0	1	.01

[1]Note: a: STD= Standards b: RA= Ratios

(Adopted from Liu, Zhang, Liang, Fulmer, Kim, & Yuan, 2009)

Table 4. New York State Regents Physics Exam Based on Points[1]

	Remember		Understand		Apply		Analyze		Evaluate		Create	
	STD[a]	RA[b]	STD	RA	STD	RA	STD	RA	STD	RA	STD	RA
Energy	0	0	3	.04	11	.13	0	0	0	0	0	0
Motion and Forces	1	.01	10	.12	19	.22	0	0	0	0	0	0
Electricity	0	0	7	.08	6	.07	0	0	0	0	0	0
Waves	1	.01	10	.12	11	.13	0	0	0	0	0	0
Properties of matter	1	.01	2	.02	3	.04	0	0	0	0	0	0
Subtotal	3	.04	32	.38	50	.59	0	0	0	0	0	0

[1]Note: a: STD= Standards b: RA= Ratios

(Adopted from Liu, Zhang, Liang, Fulmer, Kim, & Yuan, 2009)

5. Proposed Revisions

For resolving the issue of the comparative significance of different levels of objectives, the simple principle is that the more complex the level of objectives should have, the higher the numerical value. This can be done by multiplying the entries in the columns by some factors. The value of this multiplying factor should depend upon the complexity level of the objectives. As the complexity level of objectives increases across the columns, the multiplying factor should also increase in the same way. However, finding the exact value of multiplying factories is really a complex matter because there is no quantitative measure of the increasing complexity of the different levels of objectives.

The other way is to calculate AI for every category of cognitive demand separately. It will point out particular areas of misalignment. It will also solve the issue of the impact of a larger total number of objectives and scores upon the ratio scales. The good figure for the total number of objectives or scores is 50. However, the total number of objectives or scores should not exceed 100. If we recalculate the alignment measured by Liu et al. (2009) with respect to every category separately, it becomes clear that there is good alignment with respect to understanding and applying categories. Conversely, there is misalignment with respect to other categories.

The issue, unequal number of objectives/items/scores in the tables to be compared, can be resolved by adding one extra column in both the tables. The table with maximum number of items objective/items/scores will contain cells with zero entries. On the other hand, the table with deficient number of objectives/items/scores will contain in each cell the number of deficient objectives/items/scores in that row. This will bring each and every number having ratio on the same pattern. The assigning of different ratio to same number is significant. For example, if we add another column in the work of Liu, et al, (2009), the AI becomes 0.75 rather than 0.80. According to Liu, et al, (2009, p. 784) the critical value was 0.78(from the random sampling distribution). Moreover, the critical value given by Fulmer (2010) for 90 standard points and 30 cells is 0.8748. So, the new AI value changes the results from alignment to misalignment.

The below table 5 shows the proposed revision in SEC.

Table 5. Example of proposed revisions in SEC

	Rember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
	0	.07	.06	.28	0	0
	.33	.04	.03	.14	0	0
	0	.07	.04	.29	0	1
	.33	.08	.02	.29	0	0
	.33	.13	.01	0	0	0
Total	1.00	0.40	.15	1.00	0	1.00
Alignment Index (AI)	0.50	0.80	0.92	0.50	1.00	0.50
		Average				0.70

6. Conclusion

There are two important aspects that have not been considered properly in the SEC alignment measurement method. The first one is the degree of emphasis upon different levels of the cognitive domain, and the other is the difference in the numbers of objectives/items between the two documents. The present paper explores the effect of these important factors upon the measurement of curriculum alignment and suggests possible measures to improve the quantitative measurement of curriculum alignment. In fact, the study would improve the method of curriculum alignment. The improved method would in turn help in improving the quality of instruction and assessment.

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