Proposing a Validation Tool for IMO Model Courses to Evaluate Alignment of Outcomes, Activities, and Assessment

Paul S. Szwed[1,*] and Michael E. Manuel[2]

[1] *Massachusetts Maritime Academy, USA*
[2] *World Maritime University, Sweden*
[*] *Corresponding author: pszwed@maritime.ed*

Abstract: Whether informed by backward design, constructive alignment, outcomes-based education, or even essentials formulated decades earlier, there appears to be strong convergence that there should be coherence among learning objectives and/or outcomes, learning (or instructional) activities, and (learning) assessment. The maritime education and training (MET) community has widely adopted this coherence model and it is being implemented to various degrees. Recently, the International Maritime Organization has taken another step in developing its outcomes-based training policies by adopting verb taxonomies to develop learning outcome statements for model courses. However, there is evidence some IMO model courses may lack alignment between their stated overarching aim and their learning domain coverage as a recent analysis of Model Course 1.20 (Fire Prevention and Firefighting) has shown. Using the validation method developed by Cambridge Assessment, this study evaluates the alignment of domain coverage for IMO model course 1.21 (Personal Safety and Social Responsibility). Since the safety culture literature and conservation literature indicate that affect is an important determinant of pro-safety and pro-environmental behaviors, it was anticipated that this model course would have a substantial portion of affective domain coverage evidenced in its learning outcomes. However, it was found that this course has a preponderance of declarative knowledge and mental procedure outcomes and few affective, psycho-motor procedures, and interpersonal skills. Additionally, this study explored coherence between learning outcomes and instructional methods using existing frameworks as well as coherence between learning outcomes and assessment methods using existing frameworks. The authors will make the case that a method for validating coherence among learning objectives and/or outcomes, learning (or instructional) activities, and (learning) assessment is needed in the MET community – as has been done in the IMO's sister organization International Civil Aviation Organization.

Keywords: Alignment, Outcomes Assessment, Model Course, STCW, Maritime Education & Training

1. Introduction

Scholars have long made the case that there should be coherence among learning outcomes, instructional (or learning) activities, and learning assessment. For example, Spady (1994) described outcomes-based education as a form of education where "everything in an educational system" is focused and organized "around what is essential for all students to be able to do successfully at the end of their learning experiences." Biggs (2003, 1999) coined the term "constructive alignment" and emphasized that there should be "coherence between assessment, teaching strategies, and intended learning outcomes in an educational program." Wiggins, Wiggins, and McTighe (2005) proposed "backward design" as a method for achieving coherence. In backward design, desired results are identified first, then identifying which evidence will be acceptable to demonstrate achievement of the desired results, and finally learning experiences and instruction are planned. However, this idea of coherence is not new; decades earlier, Tyler (1951) introduced basic principles of curriculum and instruction that included the notion of coherence. This is often represented as a trio of interrelated elements (Figure 1).

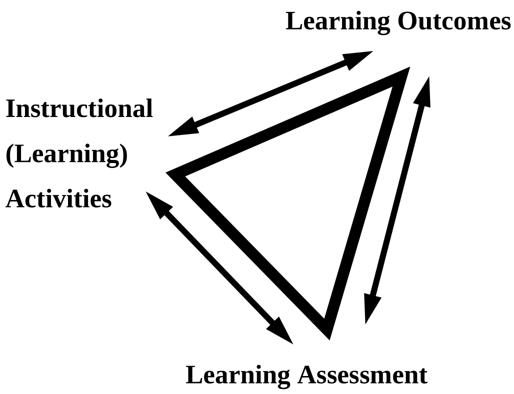

Figure 1: Illustration of Coherence

Maritime education and training (MET) institutions have widely recognized the importance of outcomes-based education. In fact, the recent publication of the Global Maritime Professional (GMP) Body of Knowledge (BoK) provides a framework for identifying relevant learning outcomes. However, proper outcomes identification alone does not ensure the outcomes will be achieved. It is also necessary to ensure instructional (or learning) activities and learning assessment are also aligned to the outcomes.

Therefore, this paper will propose a method for examining alignment between outcomes, activities, and assessment. Using a previously demonstrated method (Szwed, Hanzu-Pazara, & Manuel, 2021), it will first examine coherence with learning outcomes through mapping content/domain coverage. Then, it will more generally explore how alignment can be evaluated across an entire course (learning outcomes, learning activities, and learning assessment). Finally, it will present a framework for applying the notion of coherence model courses and more generally to any MET course.

2. Domain Coverage of Representative Model Course

Even before alignment can be considered, instructors and instructional designers must ensure an appropriate selection of learning outcomes to guide a development and delivery of the course, and assessment of learning. A course evaluation process developed by Cambridge Assessment (Suto, Greatorex, & Vitello, 2020) was found suitable for validating learning domain coverage in IMO model courses (Szwed, Hanzu-Pazara, & Manuel, 2021). That study evaluated the IMO's foundational model course in firefighting (MC 1.20) and found an imbalance between aims of the course and domain coverage (i.e., 75% of course was devoted to transmitting information, despite the action-orientation of firefighting). This study extends that work by examining the IMO's foundational course in health, safety, and the environment (MC 1.21). The method for mapping learning domain coverage followed the same five-step method (contained in Figure 2).

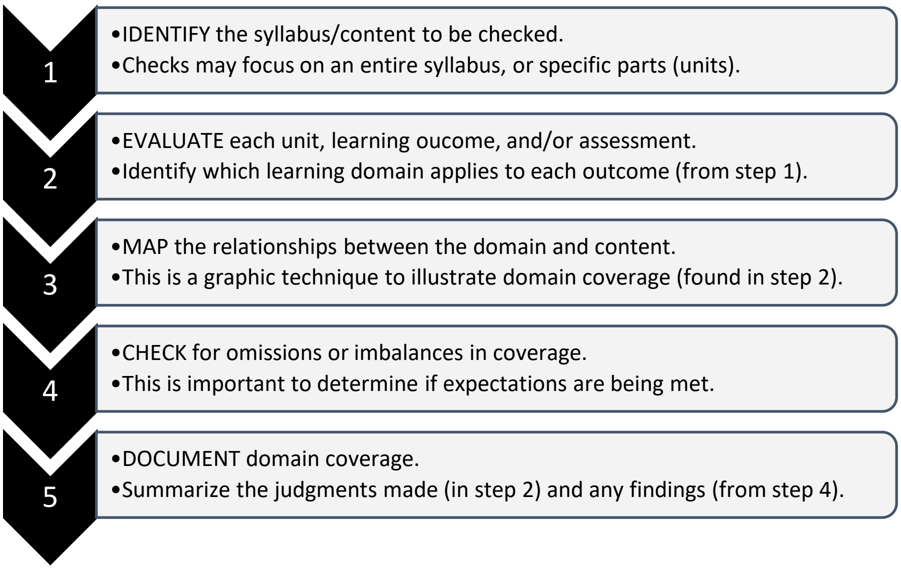

Figure 2: Method for Mapping Learning Domain Coverage

2.1 Step 1

This study examined the baseline training for health, safety, and environment (HSE). Specifically, the study examined the IMO Model Course 1.21 Personal Safety and Social Responsibilities (2016 edition – electronic). This model course was selected because it is the essential HSE training needed by all seafarers (and prospective seafarers) prior to employment on sea-going ships[1]. The model course is broken down into seven primary competencies:

1. Introduction
2. Comply with emergency procedures
3. Take precautions to prevent pollution of the marine environment
4. Observe safe working practices
5. Contribute to effective communication on board ship
6. Contribute to effective human relationships on board ship
7. Understand and take necessary actions to control fatigue

2.2 Step 2

This study evaluated each of the 147 knowledge, understanding, and proficiency performance criteria contained in the IMO safety, health, and environment course (as specified in the detailed teaching syllabus – Part C of the model course). Each evaluator[2] judged whether an outcome was an informational task, mental procedure, psychomotor procedure, or interpersonal procedure.

2.3 Step 3

Domain coverage was tabulated for each of the seven competencies and for the course overall. In contrast to the previous study of the IMO model course in firefighting, this study only reported the percentage of outcomes devoted in each domain for each of the seven competencies. We did not attempt to determine how the approximate time (as specified in the course outline – Part B of the model course) was allocated to each outcome.

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[1] A number of other courses relate to more specific aspects of safety e.g., firefighting and survival at sea.

[2] The two authors served as evaluators in this study. Both have extensive experience with MET (maritime education and training), knowledge of outcomes assessment and taxonomies, and some direct knowledge with HSE.

2.4 Results

Table 1 provides a mapping of competency/content to the learning domain affiliated with the performance criteria within the competency.

Table 1: Breakdown of Learning Outcomes Allocated to each Competency (IMO Model Course in HSE) with Mapping to Relevant Learning Domain

					Approx. Time (hours)	
Competence/Content	**Information**	**Mental Procedure**	**Psychomotor Procedure**	**Interpersonal Procedure**	**Lectures & Demos (Hours)**	**Practical Work (Hours)**
Introduction	1.4%				**1.0**	
Comply with emergency procedures	6.1%		1.4%		**1.5**	**0.5**
Take precautions to prevent pollution of the marine environment	15.6%				**4.0**	
Observe safe working practices	25.9%	0.7%	0.7%		**3.5**	**0.5**
Contribute to effective communication on board ship	15.0%	0.7%		2.0%	**2.0**	**1.0**
Contribute to effective human relationships on board ship	14.3%				**2.5**	
Understand and take necessary actions to control fatigue	16.3%				**1.5**	
	96.4%	**1.4%**	**2.1%**	**2.1%**	**18.0**	**2.0**

Virtually all of the outcomes (140 of 147) were devoted to transmission of information. It should be noted, however, that there were psychomotor and/or interpersonal procedure outcomes in each of the three competency areas with time devoted to practical work (which would seem to imply psychomotor and/or interpersonal procedures, as well as mental procedures). In addition to the Cambridge Assessment method for examining domain coverage in the syllabus, this study also examined action verb usage in the development of the performance criteria (which serve as detailed learning outcomes). Figure 3 provides an illustration of how often specific verbs were used in the 147 knowledge, understanding, and proficiency performance criteria contained in the IMO SE model course.

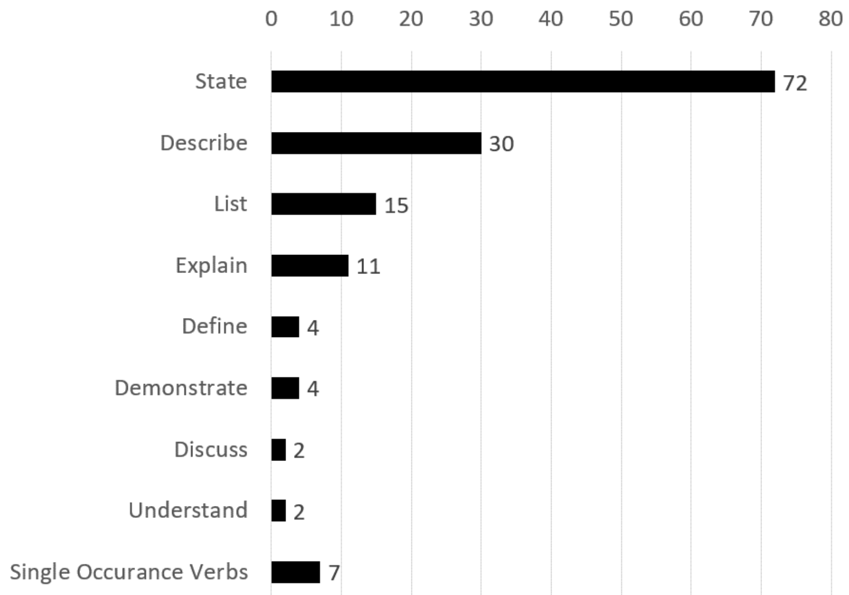

Figure 3: Frequency of Action Verb Usage in IMO Model Course in HSE

2.5 Discussion

There appears to be an imbalance between the overarching objectives stated in the course outline and the learning objectives provided in the detailed teaching syllabus. Five of the seven primary competencies have action-orientation: comply, take, observe, and contribute (in two different contexts). However, as noted in Table 1 and Figure 2, a preponderance of the objectives is crafted to transmit information or declarative knowledge. This imbalance aside, the overarching aim of the course is to prepare seafarers for the transition from shore to sea and alert them to the vastly different living and working environment. However, when it comes to HSE, learning that is affective, behavioral, and interpersonal has been found most effective to ensure a lasting change in perspective (e.g., Oltedal & Lützhöft, 2018; Schultz, 2011). Additionally, further examination of individual lesson plans for each module with practical work would be necessary to determine if the few outcomes devoted to them are sufficient.

3. Aligning Outcomes, Activities, and Assessment

This section will examine a method for constructive alignment.

3.1. A Taxonomy for Teaching, Learning, and Assessing

Perhaps the most widely used taxonomy of educational objectives is Bloom's taxonomy (1956) for the cognitive domain – which represents a spectrum of objective categories (i.e., knowledge, comprehension, application, analysis, synthesis, and evaluation). In 2001, Anderson and Krathwohl updated and revised Bloom's taxonomy. One of the notable revisions was the inclusion of two dimensions (cognitive processes and knowledge). Generally, objectives are stated as a verb (i.e., action) in combination with a noun (i.e., object). They noted that the verb described the intended cognitive process, while the noun generally described the knowledge students were expected to acquire or construct. For example, from the model course examined (see Section 2), the third objective in the second competence states that the trainee is expected to: "Describe (verb or cognitive process) procedures (noun or knowledge) adopted on board to minimize marine pollution."

In their book, Anderson and Krathwohl (2001) provide a "taxonomy table" where the cognitive process dimension is listed across the top and the knowledge dimension is listed down the side. There is a separate column for each of the six categories in the cognitive process dimension (i.e., remember, understand, apply, analyze, evaluate, and create) and there is a separate row for each of the four categories in the knowledge dimension (i.e., factual knowledge, conceptual knowledge, procedural knowledge, and meta-cognitive knowledge). A learning objective could be placed in any one of the 24 different combinations of the cognitive process dimension (6 categories) and the knowledge dimension (4 categories). The example learning objective above from the IMO model course might be placed in the "remember" category for cognitive processes and the "procedural knowledge" category of knowledge. Heer (2012) developed a useful guide for employing the two-dimensional framework of Bloom's revised taxonomy (see link provided in reference).

Anderson and Krathwohl (2001) also present a series of vignettes of actual learning scenarios to illustrate how to use taxonomy table to illustrate alignment/coherence, or lack of it. By placing the learning objectives, instructional (or learning) activities, and assessments on a series of taxonomy tables, (mis)alignment becomes apparent. To simplify the display of this concept, we will introduce the following notation:

- Objective[3] – a dot will be placed in the center of each box pertaining to each of the objectives.
- Activity – the upper half triangle of each box will be shaded for each of the instructional activities.
- Assessment – the lower half triangle of each box will be shaded for each assessment.

The following completed taxonomy table (see Figure 4) illustrates the alignment analysis for the "Nutrition" vignette, which is a real curricular unit that was analyzed by a team of experts. This vignette demonstrated moderate alignment as evidenced by the coverage of the shaping and the proximity to the objectives. If there had been strong (or perfect) alignment, each box with a dot would have been fully shaded. You are encouraged to refer to the source for a complete description of the analysis.

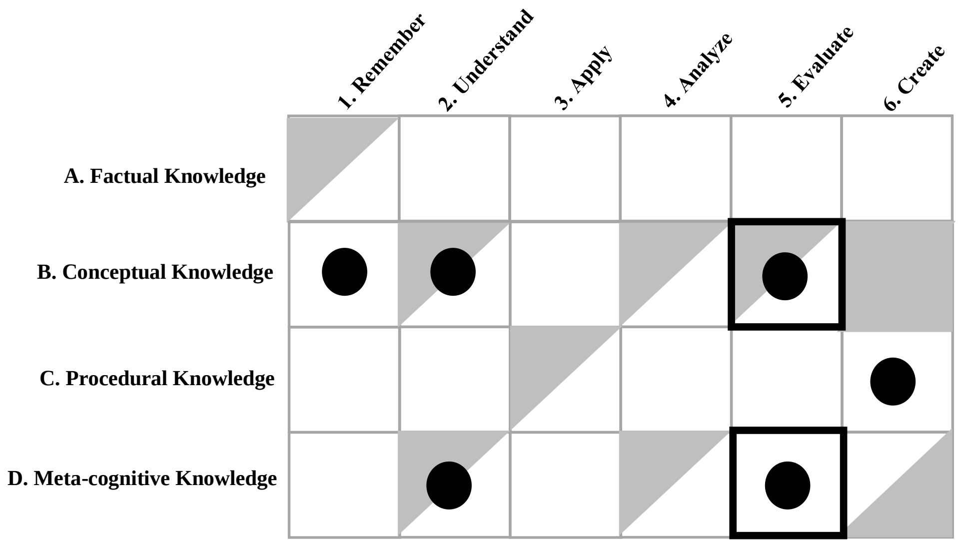

Figure 4: Alignment Mapping of Objectives, Activities, and Assessments for Sample Learning Module

By mapping each outcome, activity, and assessment is such a way, it is possible to observe instances of gaps or overlaps in the intended treatment of the subject/learning, as well as (mis)alignment. Applying such an analysis to model courses and the requisite lesson plans would demonstrate a strong commitment to outcomes-based education. This taxonomy table scheme could be used as an advanced tool for validating model courses. The part that is notably absent is the tacit knowledge of the experts who evaluated the vignettes:

- What types of instruction are well suited to the different learning objectives?
- What types of assessment are well suited to the different learning objectives?

Unfortunately, the answers to these two questions are not codified into any singular source or resource. Instead, various attempts have been made to address these questions. The next two sections will highlight some of those attempts.

[3] While Bloom's work used the word "objectives", a more recent emphasis on "learning outcomes" is perhaps appropriate given the increased prominence of outcome-based education in maritime education and training.

3.2. Aligning Instructional (or Learning) Activities to Outcomes

A search was conducted to identify sources of matching or aligning instructional methods to learning objectives, but an apparent strain of literature did not immediately emerge. Instead, several examples were found that either explicitly or implicitly illustrated such matches.

Nilson (2001) provided a table of 17 teaching methods and which specific categories in the cognitive dimension (e.g., six cognitive process categories within Bloom's taxonomy) they were most effective in developing. For example, lectures were considered most effective for developing (declarative) knowledge. Whereas, an interactive lecture also supported development of comprehension (and possibly all others depending upon features of interactive lecture). In contrast, a teaching method like roles plays and simulation would be effective at developing application, analysis, and evaluation (i.e., the higher order categories of the cognitive process dimension). While Nilson's book (and table) were created before the revised Bloom's taxonomy was published, it is envisioned that such a matrix could be used for selection of instructional method to best align with identified learning outcomes. This table would be helpful in that it contained a wide variety of typical classroom and field-oriented teaching methods. Also, it might be used retrospectively to evaluate alignment/coherence.

Another more recent attempt at matching instructional strategies to knowledge types called the "Instructional Strategies Framework" was proposed by Wallcott, Fiorella, and Malone (2013). This framework was prepared to inform development of training, which would be highly relevant to model courses. While it viewed training as having three phases (i.e., prior-, during-, and post-training), the during-training instructional strategies included three main classes of training events: presentation, guidance, and practice (which were further subdivided). Each of these indicated the appropriate level of expertise of the training (e.g., novice, journeyman, and expert) as well as the knowledge type (e.g., declarative, procedural, conceptual, and integrated). These knowledge types are similar in nature to the found in the knowledge dimension of Bloom's revised taxonomy (Anderson & Krathwohl, 2001). For example, signaling (presentation), worked out examples (guidance), and distributed practice (practice) were identified as effective for supporting development of declarative knowledge. In contrast, distributed practice (practice) and cognitive apprenticeship (guidance) were considered effective for supporting development of integrated knowledge. This framework would be helpful in that it grouped instructional strategies and provided underlying instructional principles as well as supporting research.

Weston and Cranton (1986) published an article about selecting instructional strategies. In general, these were summarized as being in one of four different categories of instruction: a. Instructor-centered, b. Interactive, c. Individualized, and d. Experiential Learning Methods. For each of the learning domains (i.e., cognitive, affective, and psychomotor), they identified (or matched) appropriate instructional (or learning) methods to each category within each dimension. For example, in the affective domain, among several others, it suggested lecture and discussion for receiving, discussion and simulation for responding, simulation and projects for valuing, projects and field experience for organizing, and field experience and independent study for characterizing. The four summary categories presented would be useful for creating a framework for classifying instructional methods. A similar categorization approach was proposed for the Saskatchewan educational system (1991) and it included five groupings of instructional strategies: a. direct instruction, b. indirect instruction, c. experiential learning, d. independent study, and e. interactive instruction. There are similarities and overlaps between the two frameworks. We propose a typology that uses two dimensions to define the categories of instructional strategies and methods. First, it appears both of these categorizations include some notion of locus for responsibility – we have defined these as: teacher-centric, learner-centric, and shared-responsibility. Additionally, since both of the categorizations include what appears to be instructional strategies found in the classroom and those from experiential learning, we propose a dimension for where the learning takes place: classroom environment, performance environment (which is especially important for professional training), and a simulated environment (since this is a key context within MET). Figure 5 illustrates how instructional methods may be placed in each of the resulting intersections of this typology.

Learning Environment	Locus of Responsibility: ***Teacher-centric***	***Shared Responsibility***	***Student-centric***
Classroom	Lecture	Case Study	Independent Research
Simulated	Simulation Exercise	Laboratory	Role Play
Performance	Drill & Practice	Field Study	Internship

Figure 5: Typology of Instructional Methods/Strategies based on Locus and Learning Environment

It could be envisioned that cognitive outcomes could be developed across any combination of locus and environment, that affective outcomes would best be learned on the portion with more student-centrism, and that affective outcomes would best be learned in simulated and performance environments. However, until such time as a study has been performed or a theory has been proposed that measures or assesses goodness of fit between the category of each learning outcome and proposed instructional (or learning) methods and strategies, we will focus on assessing the coverage of fit (from the taxonomy tables) as described earlier.

3.3. Aligning Learning Assessment to Outcomes

Similarly, it would be beneficial to evaluate alignment between learning outcomes and learning assessment methods. Here too, there is an apparent gap in the literature. There have been a few attempts to create a classification scheme to develop coherence. For example, in the context of business schools (mainly in an effort to demonstrate suitable learning assessment for accreditation purposes), Rubin and Martell (2009) provided a classification of assessment methods for learning outcomes in each main learning domain (cognitive, affective, and skills-based or psychomotor). In their example, they suggested exams were effective at assessing verbal (declarative) knowledge, concept mapping as effective at assessing knowledge organization, and case scenarios as effective at assessing cognitive strategies. For affective outcomes, the indicated attitude could be assessed indirectly through self-reporting and that motivation could be assessed directly through observation (e.g., time on task, team engagement, etc.). In a similar effort, Shannon et al. (2000) devised a scheme for matching assessment methods to outcomes in their context of engineering education. However, since the matrix of outcomes and methods was nearly fully covered, it was determined this matching scheme was less useful and mainly pointed toward a need for further research – which we agree with. There are also several resources that provide matches to classroom (formative) assessment techniques rather than summative assessment techniques. While interesting in concept, it seems this idea of matching assessment to outcomes is less well-developed than matching methods to outcomes. Therefore, we propose assessing the coverage of fit (from the taxonomy tables) as described earlier.

4. Conclusions

After evaluating the objectives of two foundational model courses (namely MC 1.20 and MC 1.21), it appears more focus might be devoted to ensuring learning outcomes adequately cover the intended domains of learning. Specifically, it would be beneficial that affective aspects, psychomotor procedures, and interpersonal procedures are adequately represented in the outcomes (as indicated by overarching objectives), in addition to the more traditional cognitive aspects (e.g., information and mental procedures). It would seem that in addition to the two-dimensional revised Bloom’s taxonomy for cognitive aspects of learning, other taxonomies should be referenced to ensure affective, psychomotor, and interpersonal aspects of learning were suitably considered. Examples could be drawn from any number of taxonomies as illustrated in Figure 6.

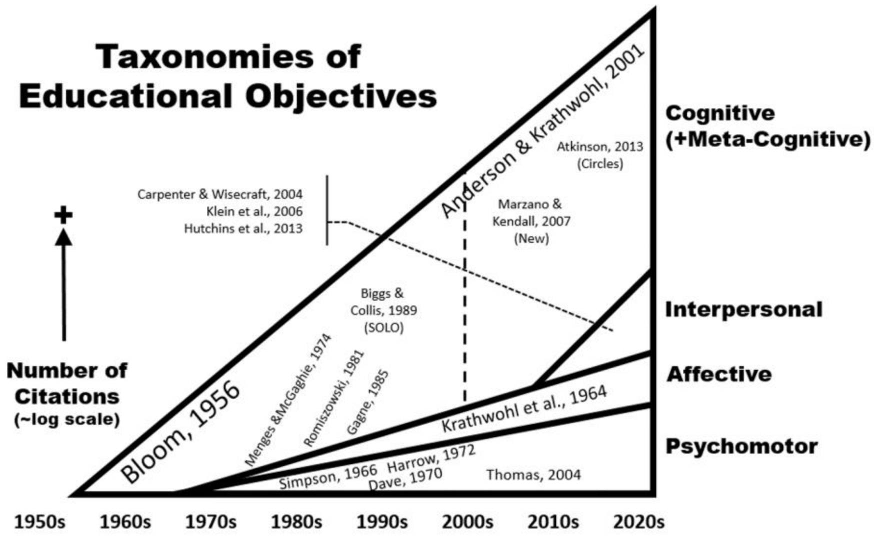

Figure 6: Developmental Progression of Taxonomies of Learning Objectives/Outcomes

However, even more importantly, the concept of alignment (or coherence) might be more formally established in the IMO model course framework. At present, the greatest focus is on learning objectives (stated as competencies for knowledge, understanding, and proficiency). Model courses provide a sample lesson plan, but learning (or instructional) activities are left to instructors and instructional designers. Further, the model courses provide general assessment concepts, but limited discussion of how best to align specific assessment to instructional (or learning) activities and the learning objectives they are intended to deliver. As a result, no alignment can be guaranteed. Using a framework such as the taxonomy tables (Anderson & Krathwohl, 2001), much more intentional alignment course be achieved in design and/or validation of IMO model courses.

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