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A new model for organizing curriculum alignment initiatives

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Shaltry C. A new model for organizing curriculum alignment initiatives. Adv Physiol Educ 44: 658–663, 2020; doi:10.1152/advan.00174.2019.—The author discusses the benefits of curriculum alignment and the development of a new database system called e-CMS (electronic curriculum mapping system) for organizing curriculum alignment initiatives. Fundamental to the systematic organization of curriculum is understanding the interplay between three alignment factors present in all courses: assessments, TLAs (teaching and learning activities), and objectives, also known as the triadic model of alignment. Also important to this process is the inclusion of external alignment factors, such as cognitive level, professional skills, and the core concepts of physiology. When organized properly, alignment of internal and external factors provides a common language for discussing and comparing courses across departments and institutions. Databases such as e-CMS not only help organize curriculum, but also offer almost unlimited ways to combine, analyze, and share resultant data. This could provide value to students and their future employers by communicating with confidence the evidence-based knowledge, skills, and abilities gained in a course or program. The next phase of the alignment initiative that playd e-CMS is to develop a distributed online database for housing and sharing aligned assessments.

INTRODUCTION

This examination of a new model for curriculum alignment using database technology grew out of work of the Physiology Majors Interest Group, or P-MIG, a grassroots organization that was formed to help develop international programmatic guidelines for undergraduate degrees in the discipline and to serve those engaged in undergraduate physiology-related programs. One of the primary committees of this group is working to utilize the core concepts of physiology standards, originally described by Michael et al. (3), to help guide these efforts. One goal of the examination presented is to provide an uncomplicated and sustainable method for facilitating the alignment of curriculum within and across courses, programs, and institutions. The core concepts of physiology examined here serve as just one example of the type of curricular data that can be used in alignment. The alignment methods and technologies presented can flexibly accommodate any type of curriculum (e.g., laboratory, lecture) or standards.

There are many possible starting points for an alignment initiative. Where to begin depends on prior knowledge and the current state of course or program development. For example, some participants may have no familiarity with alignment or objectives, whereas others might already have a fully aligned course and are just looking for a better way to organize data. The suggested sequence, technologies, and methods presented are intended to create a shared understanding of the alignment process (and often-confusing terminology), regardless of the starting point of participants.

Foundations of Alignment

There are two types of alignment: internal and external. Internal alignment is the process of ensuring that the three elements of a course, teaching and learning activities (TLAs), assessments, and objectives, are aligned. Internal alignment among these three elements is referred to as triadic alignment (6). Internal alignment ensures that the three elements are aligned both conceptually and cognitively, but does not provide a means of comparing curriculum across courses.

External alignment uses standardized factors, which are independent of a single course (e.g., core concepts of physiology, professional skills), to provide a shared language for discussion and comparison. It is recommended that courses are aligned internally first. "By aligning our learning activities with our assessments and our assessments with our learning outcomes, we provide greater opportunities for students to demonstrate what they have learned" (2). Once internal alignment is achieved, courses can be aligned externally to provide points of comparison across courses.

Some factors can be used for both internal and external alignment. For example, Bloom’s taxonomy can be used internally to ensure consistency of cognitive levels within courses and externally as a shared, standardized language for discussing and comparing courses and programs. This is because inherent within properly written objectives are verbs indicating the Bloom’s level (e.g., recall, analyze). Assuming assessments and TLAs have already been conceptually aligned, aligning them to objectives using Bloom’s cognitive levels (intrinsic to properly written objectives) would ensure greater internal consistency while providing a mechanism for external comparison. For example, a properly aligned assessment item written at the “apply” level of Bloom’s requires an objective written using an action verb denoting application of a concept or skill and TLAs designed to facilitate this practice.

The Importance of Alignment

From a pragmatic perspective, alignment matters because grades matter. Grades are one of the few mechanisms available to efficiently communicate assessment of student learning. Ensuring course assessments (which produce grades), TLAs and objectives are clearly defined and conceptually connected to one another, which is an important part of ensuring grades...
accurately represent the operationalization of the knowledge, skills, and abilities that the syllabus claims a student gained in a course (e.g., an “A” indicates mastery). Research also suggests that students perform better in courses that are internally aligned (2, 6).

Proper alignment can also increase the effectiveness of curriculum conversations. Discussions attempting to identify overlaps and gaps in the curriculum are often limited to vaguely defined topics. The lack of fidelity in these conversations can limit their value to course and program improvement. Having a common language allows instructors to compare, for example, the frequency and depth of core concept coverage. For example, having the capability to report on how often courses across a program focus on the external standardized physiology core concept, “Homeostatic processes require target organs or tissues, i.e., ‘effectors’,” (3) could help identify whether this concept is being covered too much (overlaps) or too little (gaps) within a given program or how it compares to other programs. Knowing this might facilitate rich discussions of similarities, differences, and rationale of curriculum choices among instructors and/or institutions. Other external factors, such as program standards, Bloom’s level of assessments, and professional skills standards, might also encourage rich discussions across courses and programs.

The Impact of Misalignment

The effects of misalignment often manifest in three ways: within a course, between courses/programs, and beyond the school in which a course resides.

A 2010 study found that course goals (objectives) were written at higher cognitive levels than assessment items, yielding no statistical relationship between these two course elements (4). The study suggests that lack of cognitive alignment between course goals and assessments may be widespread, at least in the biological sciences, after surveying 77 undergraduate biology courses from across the country. Similar to later alignment studies (2, 6), this study used Bloom’s taxonomy as the factor of comparative analysis. Since course goals did not align with assessments in this study, it stands to reason that course TLAs are also misaligned, at least cognitively. This could result in a disadvantage for students when attempting to learn new concepts and skills.

Within a course, students may also experience cognitive overload and stress when trying to compensate for misalignment (e.g., a lack of relationship between TLAs, objectives, and assessments). “Cognitive load, a multidimensional construct, represents the load that performing a particular task imposes on the cognitive system... The intensity of effort expended by students is often considered the essence of cognitive load” (5). In content-dense courses, for example, it is a common direction for students to know everything for the test, or similar variant. In these scenarios, guidance and focused practice opportunities (e.g., practice quizzes) can be portrayed as catering to laziness, not as beneficial types of TLAs.

It might be argued that overload and stress are good and implicitly serve to teach students how to critically discern relevant from irrelevant information. Since life is rarely straightforward in its presentation of problems, it is good to learn these skills in a controlled classroom environment before encountering high-stakes situations in the “real world.” Therefore, it is best to practice these skills now to prepare students for this reality.

While this might seem rational, the implicit curriculum of problem solving in complex situations presented by misalignment is likely not intentional and could reduce motivation and increase failure (5). In the professional world, attending a poorly planned meeting or presentation does not often leave participants appreciating the opportunity to hone their skills in deciphering badly constructed slides or figuring out the aim of a meeting. Rather, participants are often left with the sense that their time could have been more productively spent had the meeting or presentation been more carefully planned. Similarly, it is plausible that students will get much more out of a course in which assessments, TLAs, and objectives are aligned (2, 6).

Between courses and programs, misalignment can also lead to students being under prepared and overwhelmed or, in some cases, over prepared and bored. For example, one might conclude that a student achieving an “A” in a laboratory course where blood pressure is listed as a topic will be competent in taking blood pressure. However, without the constituent objectives of this topic, how it was taught or assessed, this conclusion may be false. It is possible the student learned the theory of blood pressure and how it impacts the body, but not how to take blood pressure. In this example, a nursing student may be under prepared going into a future course in which this skill is assumed. A student headed for a graduate research program in physiology, on the other hand, may be well prepared, as they are versed in the theory necessary for their program. In this scenario, organizing and clearly communicating what was learned and how might have prevented the nursing student from being under prepared for the next course.

In the professional world, it is common for employers to make assumptions about candidates based on transcript grades, published syllabi, and degrees granted. These components summatively reflect the body of knowledge, skills, and abilities acquired by students through degree-granting programs. In other words, the quality of a degree is dependent on the TLAs, objectives, and assessments that make up each course in the program. For example, two students might graduate with physiology degrees from different institutions. On the surface, the students have acquired the same degree. However, one student’s program may have included professional skills in the curriculum, whereas the other student’s program did not. Once we delve into the specific aspects of the courses in each program, important qualitative differences between the two degrees begin to emerge.

A Model for Facilitating Alignment: Internal

The first step in aligning curriculum is to align internally using the triadic model, ensuring conceptual consistency across all three elements: TLAs, assessments, and objectives. The electronic curriculum mapping system (e-CMS) database is used to facilitate the organization of both internal and external alignment data. The diagrams in Fig. 1 are used for conceptual demonstration only.

“TA” represents the alignment between TLAs and assessments. Aligning these elements means that assessment items in a course have a direct relationship to the activities performed (e.g., lectures, note taking, readings) by students. TA-aligned
Courses will include TLAs that can be mapped directly to individual assessment items, with TLAs often contributing toward the end of course grade, and the assessments almost certainly contributing.

“AO” represents the alignment between course assessment items and objectives outlined by the instructor. Aligning these elements means that assessment items in a course have a direct relationship to one or more objectives. AO-aligned courses will include objectives that can be mapped directly to individual assessment items, which count toward the end-of-course grade.

“TO” represents the alignment between course TLAs and the objectives outlined by the instructor. Aligning these elements means that the TLAs of the course have a direct relationship to one or more objectives. TO-aligned courses will include objectives that can be mapped directly to TLAs, which often contribute to the end-of-course grade.

“TAO” embodies all three of the above alignment combinations within a single course. Full triadic alignment means that TLAs, assessments, and objectives all connect with one another via one or more factors (e.g., conceptually, cognitively). For example, in a TAO-aligned course, a single objective can be traced directly to both an assessment item and a TLA in a course.

By nature, current courses already implicitly contain the three elements. However, the element “objectives” is often absent or improperly formatted (i.e., “Student will understand [H1127]”). Instructors can extract and align these objectives using the strategies provided below. It is recommended that these elements be generated using the backward design development process in which objectives are developed from assessments and TLAs are selected using objectives (7). Existing objectives, such as the core concepts of physiology, could also be adopted and integrated into these alignment strategies.

Figure 2 illustrates the process of deriving objectives and competencies from assessments. Competencies are simply performances consisting of multiple objectives. Just as inherent within every objective is a cognitive level, inherent within every assessment is one or more objectives. Translating assessments into objectives can vary in difficulty, depending on how assessments are written. Occasionally, assessment items translate almost word-for-word to objectives. For example, an assessment item that reads, “Identify the parts of a blood pressure cuff,” could be translated into an objective that reads, “Student will be able to identify the parts of a blood pressure cuff.” A skill assessment such as, “Manually measure blood pressure and explain to the instructor the steps involved and the meaning of the results,” might be broken down into several different objectives (e.g., “Student will be able to identify the parts of a blood pressure cuff”) that contribute to mastery of this skill.

Depending on the starting point of the alignment initiative (e.g., “We have objectives and TLAs selected, but no assessments yet”), conceptually aligning TLAs to objectives (Fig. 3) should also conceptually connect assessments to TLAs (via objectives) once assessments are developed and aligned to objectives. Once all three elements are aligned conceptually, it is recommended to add Bloom’s cognitive levels to the process. Aligning objectives using cognitive levels should be straightforward, as they should already contain verbs indicating level. Aligning assessments using cognitive level may be slightly more difficult if they are not written using the same verbs as the objectives. In this case, instructors must ask themselves precisely what it is they are asking students to do in the assessment and decide the level required to perform the desired task. The process of aligning TLAs requires reflection and subjective judgment of the teaching strategies, content selection, and practice that will help students most. This process usually improves with experience and continual reflection. Internal alignment with Bloom assumes prior conceptual consistency, adds cognitive consistency, and provides a path to expanding alignment to additional external factors, since Bloom is both an internal and external factor.

A Model for Facilitating Alignment: External

Once the three elements are aligned internally, the next step is to add external factors (e.g., core concepts of physiology, professional skills) to the process to promote consistency.
beyond a single course. Adding external factors can provide a standardized language for “apples-to-apples” comparison of content across different courses. If the context of two different courses is housed within the same database, such as e-CMS, this process simply requires the application of a filter (e.g., display content across all courses that are tagged “Bloom’s level 1”). This can help with initiatives focusing on more than a single course, such as program evaluation.

Organizing Internal and External Alignment

We know alignment is important, and instructors/programs want to do it, but we have not found any good tools out there to assist, especially in ways that ensure participants will not feel overwhelmed by the process. In response, the author created a fully customizable, easy-to-use, online e-CMS using database technologies.

This system has three aims. 1) Increase continuity within and across courses and programs by identifying overlaps and gaps in the curriculum. 2) Foster the development and use of external factors of alignment for evaluating courses. 3) Provide an easy-to-use reporting tool for course assessment via internal alignment, program assessment/accreditation via external alignment, and answering questions that would be difficult or impossible otherwise.

Any of the bold labels or tables shown in Figs. 2 and 3 could be transferred to e-CMS as an alignment field (Fig. 4), similar to a column in a spreadsheet. Once set up in the database, data can be easily tagged, filtered, searched, and exported. For example, the content “Chapter 1 Reading” in Fig. 3 could be tagged in the database with the objective codes “Obj 1.2” and “Obj 1.3.” Tagging content with internal objective codes is especially helpful when trying to identify specific objectives in need of additional support.

e-CMS utilizes an easy-to-customize, affordable online subscription database service called Knack.com (https://www.knack.com/). Modern cloud technology has brought down the cost and expertise required to utilize formerly complex database systems. This is good news, because many alignment initiatives have been stuck with the limitations of shared spreadsheet matrix-type alignment systems. Although spreadsheets and matrix tick mark systems are commonplace in alignment initiatives, they tend to offer “a clumsy solution

Fig. 3. Diagram depicting the alignment of course objectives with teaching and learning activities (TLAs).

Fig. 4. Screenshot of the electronic curriculum mapping system illustrating one way that data could be organized. The column display (e.g., Learning Objective) can be customized (e.g., add a “Big Ideas” column before objectives) to fit the needs of the organization.
when dealing with data of this nature, size and complexity (1).” Some spreadsheet alignment systems try to approximate the capability of databases using features like pivot tables, simultaneous sharing, and search functions, but still cannot store, search, and sort data as efficiently as a database.

To prevent users from feeling overwhelmed by the alignment process, e-CMS allows users to customize the alignment categories and display interface (Fig. 5). For example, users can choose to display only learning objective and fields when initially inputting and organizing course curriculum data, which is similar to hiding columns or rows in a spreadsheet until they are needed. Once users have completed the visible portion of data entry, they selectively display additional alignment category fields, such as assessment type, national standards, or topics (Fig. 2). Data entry into these fields resembles spreadsheet boxes and can include a variety of data types, including check boxes, drop-down menus, and comment fields. In addition, users can be assigned different displays without corrupting the underlying data. A second user, for example, could choose to only display a national standards field without worry that the input will disrupt or corrupt that of another user. Unlike spreadsheets, the fields displayed in a database are independent of where data are stored.

Another advantage a database system has over a spreadsheet is that the data do not require prior formatting. “[M]any creators of large spreadsheets will have found themselves having to laboriously reorganize a spreadsheet, as their project progresses, in response to needs that were not initially anticipated. (Or, alternately, they find themselves using clumsy quick fixes to adapt a spreadsheet to an unanticipated need)” (1). The flexibility of separating data from formatting avoids the often-prescriptive nature of spreadsheets. It is also more difficult to add, move, or hide data fields without disrupting the workflow of others in spreadsheets. e-CMS allows users to customize the experience of data entry and presentation without altering the format or aggregation of data, making the experience easier and more user friendly for all involved.

**Development and Testing of e-CMS**

The alignment initiative on which this paper is based is ongoing. Currently, the e-CMS database houses over 600 objectives across several undergraduate physiology courses at Michigan State and other universities. In a recent informal test of the functionality and interface of the e-CMS alignment system, three separate categories of volunteers aligned the same set of 122 objectives from a single course to the core concepts of physiology. Members of each category had a background in physiology, but differed in education level. The participant categories were 1) a recent graduate from our physiology program, 2) recent graduates of our undergraduate physiology program in their gap year before medical school, and 3) a physiology doctoral student. All participants were presented the same list of basic definitions of the core concepts from *The Core Concepts of Physiology: A New Paradigm for Teaching Physiology* (3). Each category of

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**Fig. 5.** Diagram illustrating how abstract alignment factors, both internal and external, are connected to one another and displayed using database columns in the electronic curriculum mapping system.

**Fig. 6.** Diagram illustrating a recommended sequence for starting an alignment initiative. TLAs, teaching and learning activities.
The triadic model provides a method for managing the complex process of effective course design (e.g., align internally first). An aim of alignment is to ensure courses are designed to clearly and accurately communicate to students what they will learn and to outside stakeholders what has been learned. It is also intended to promote instructor reflection on rationale for selection of assessments, TLAs, and objectives to be included in a course.

Data resulting from the alignment process can be especially valuable outside a course or program for purposes such as accreditation or publicly sharing (e.g., with employers) the specific knowledge, skills, and abilities gained by students in a course or program. Databases such as e-CMS offer almost unlimited ways to filter, sort, and graph data to generate useful, targeted reports. Making alignment data public as part of an extended syllabus, for example, could promote and facilitate conversations among faculty within and beyond single institutions. Another goal would be to allow instructors to more easily track student performance on specific objectives over time for course improvement. This system would be designed to ensure replicability, low barrier to entry, and participation, regardless of institutional resources available.

This paper is published as part of a special collection/special issue from P-MIG, a grassroots organization that has formed to help develop programmatic guidelines and serve those engaged in undergraduate physiology or physiology-related programs. To find out more about this collective, or get involved, please visit our website (https://www.physiologymajors.org/) and consider joining our listserv.

**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the author.

**AUTHOR CONTRIBUTIONS**

C.S. analyzed data; interpreted results of experiments; prepared figures; drafted manuscript; edited and revised manuscript; approved final version of manuscript.

**REFERENCES**

1. Gluga R, Kay J, Lister R. Progiss: mastering the curriculum. Proceedings of the Australian Conference on Science and Mathematics Education, University of Syndney, September 26–28, 2012, p. 92–98.
2. Jensen JL, McDaniel MA, Woodard SM, Kummer TA. Teaching to the test...or testing to teach: exams requiring higher order thinking skills encourage greater conceptual understanding. Educ Psychol Rev 26: 307–329, 2014. doi:10.1007/s10648-013-9248-9.
3. Michael J, Cliff W, Mcfearland J, Modell H, Wright A. The Core Concepts of Physiology: A New Paradigm for Teaching Physiology. New York: Springer Nautre, 2017.
4. Momsen JL, Long TM, Wyse SA, Ebert-May D. Just the facts? Introductory undergraduate biology courses focus on low-level cognitive skills. CBE Life Sci Educ 9: 435–440, 2010. doi:10.1187/cbe.10-01-0001.
5. Paas FG, Van Merriënboer JJ, Adam JJ. Measurement of cognitive load in instructional research. Percept Mot Skills 79: 419–430, 1994. doi:10.2466/psm.1994.79.1.419.
6. Pape-Zambito DA, Mostrom AM. Improving teaching through triadic course alignment. J Microbiol Biol Educ 19: 1–6, 2018. doi:10.1128/jmbe.v19i3.1642.
7. Wiggins G, McTighe J. What is backward design? In: Understanding by Design. Alexandria, VA: Association for Supervision and Curriculum Development, 1998, p. 7–19.