Curriculum design and management: a systems view

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Abstract

Systems thinking has been likened to a science of organizing complexity. Few problems in education have the elements of complexity as that of curriculum. Indeed, within the educational system, the subsystem, curriculum, presents us with a design- or problem solving- challenge that requires tools and approaches that have yet to be fully explored. This paper discusses the basic systems elements of curriculum design and management and highlights the problem underlying the development of curricula that are based on networks of learning standards and benchmarks. Project 2061 Benchmarks for Science Literacy [1] is used as an example of such interconnected learning benchmarks. The first of a suite of tools, TraxLiteracy [2], which tracks benchmarks, curriculum activity blocks and student achievement is used to illustrate the dimensions of the problem and the elements of managing benchmark-based curricula. The implications for education at every level from elementary to university is discussed.

1 Background - a systems definition of curriculum

The educational literature abounds with definitions of ‘curriculum’. The assortment of contemporary definitions ranges form those of a parent, Mrs. Stephens,

“Curriculum is an eclectic framework of learning opportunities, resources, and instructional strategies that empower students to aspire to and to attain national and state standards, learner outcomes, specific teacher-based objectives, while addressing individual abilities.”.... Mrs. Stephens.
to that of a Board of Education [3],

“A series of planned instruction that is coordinated and articulated in a manner designed to result in the achievement by students of specific knowledge and skills and the application of this knowledge”

to that of George J. Posner and Alan N. Rudnitsky [4],

"Curriculum is not a process. . . . A more precise view of curriculum--and the common understanding of curriculum among lay people--is that it is what is taught in school or what is intended to be learned. It does not refer to what is to be done in school or what is to happen in the learning process. Curriculum represents a set of intentions, a set of intended learning outcomes."

The first definition sees curriculum as a set of resources and strategies aimed at empowering students to achieve various standards; the second emphasizes coordination and planning and the third puts the emphasis on the outcomes themselves. It is important that we establish a working definition at the outset. Let’s try viewing curriculum as a subsystem of the education system. There are various definitions of the term system. This paper will consider the definition of Robertshaw, Rerick and Mecca[5],

“A system is a time-varying configuration of people, hardware and procedures organized to accomplish a certain function(s).”

Viewing curriculum as a system or (subsystem of education), we can begin with a simple definition,

Curriculum is a time-varying configuration of teaching-learning activities organized to accomplish a set of benchmarks for student accomplishment.

In this paper we will use the term benchmarks, learning objectives and standards somewhat interchangeably referring to them generally as benchmarks or BMs. Likewise, we will refer to teaching-learning activities as curriculum activity blocks or CABs. CABs involve students, teachers, parents, and other participants in a planned learning activity such as a learning unit, an extended lesson, a group or individual project, etc. The specification of a CAB will be discussed later. For purposes of introduction, as long as we keep the aforementioned agreements in mind, we can use as our definition of curriculum,

Curriculum is a time-varying configuration of learning activity blocks (CABs) organized to accomplish a set of benchmarks BMs.
2 Background - systems design and complex problem solving

Systems design, which is related to engineering design, is the common thread among the engineering and interdisciplinary problem solving disciplines and is applicable to a broad range of complex problems especially those which are non-algorithmic. The methodologies have been well described in many sources. We will briefly illustrate the systems approach as described by Robertshaw, Mecca and Rerick [5] and shown in Figure 1.

When applied to a real problem, the steps are not necessarily sequential. Yet we will treat each in order and apply this thinking to the design of benchmark-based curricula. Problem definition involves identifying the objectives, deriving the constraints of the problem and establishing the value system of the customer. In the problem of curriculum design, the objectives relate to student accomplishment of learning goals, or in our jargon, benchmarks. Benchmarks may arise from different sources including state or federal mandates, institutional agreements, and partnership or affiliation requirements. Constraints include conditions arising from the time available, e.g. the length of a school day and year, the need for other activities, e.g. lunch and other non-curriculum requirements, and contractual matters, e.g. maximum teacher-student contact hours and teacher preparation time. Generating Alternatives in curriculum design involves the creation of curriculum activity blocks that address benchmarks and the assembly of these in a way that fits the constraints and meets the objectives. Evaluation of alternatives includes consideration of the order in which CABs and hence, benchmarks, are met. As we shall see, the iterative process of generating and evaluating curriculum options introduces a level of complexity that often goes unrecognized in traditional curriculum design. This complexity arises as a result of the inter-relatedness of benchmarks. There are other levels of complexity as well. Coming into a curriculum segment, every student may not have accomplished the same benchmarks or every student may have a different level of accomplishment of prerequisite benchmarks. This introduces a requirement that we closely monitor the progress of every student before and during the learning...
process. Clearly tools are needed if we are to meet the challenges of curriculum design under the aforementioned conditions.

3 Benchmarks

School districts serving K-12 are increasingly faced with standards and benchmarks from a variety of sources and in a variety of areas (types); this is shown in Figure 2. Often the benchmarks areas (types) are driven by particular sources. Examples of some of these connections are shown for the Times2 Academy, a Charter School in Providence, Rhode Island USA, is in the arrows of Figure 2. Of particular interest to this paper are the American Association for the Advancement of Science (AAAS) Project 2061 Benchmarks for Science Literacy [1]. Project 2061 grew out of a need to raise the scientific literacy of U.S. students which had fallen sharply in the decades following the late 60s. The effort drew on the talents and thinking of educators, faculty, teachers, researchers, administrators and Nobel laureates from a variety of scientific disciplines and resulted in a collection of some 800 benchmarks representing things students should know or be able to do as a result of their K-12 school experience.

The basis for each benchmark is documented in Science for All Americans, published by AAAS in 1990 [6], Benchmarks are organized into 12 chapters. So many of the topics historically included under the aegis of science literacy are not included in the Project 2061 Benchmarks for Science Literacy. Yet what is included is found on close inspection to be a set of ideas and skills that are significant and fundamental to the scientific enterprise. The great strength and the source of complexity in Project 2061 is that the benchmarks are inter-related on different levels with hierarchies that cross its chapter categories. Some of these connections are documented in the Atlas for Scientific Literacy published by AAAS in 2001 [7]. It is not the intention of this paper to discuss the specific content of Benchmarks but rather to emphasize the complexity that arises out of the connections between benchmarks in the development of a curriculum that is based on these standards. Table 1 gives a small segment with maps of interconnected Project 2061 benchmarks to be accomplished by students by grade 2. The numbers represent assigned codes for the benchmarks. Highlighted for example is benchmark number 070A02002 (chapter 07 section 0A grade 02 item 002). Moving from left to right, notice the sequence of benchmarks that arise in each map that must be accomplished before benchmark 070A02002. Of course, the complexity increases many-fold as one traces a grade 12 benchmark through its pre-requisite benchmarks.
Figure 2: Benchmarks by Source and type and sample connections source to type for Times² Academy.

Table 1: A small segment of Project 2061 benchmarks. See text.

<table>
<thead>
<tr>
<th>070A02001</th>
<th>060D02003</th>
</tr>
</thead>
<tbody>
<tr>
<td>060F02001</td>
<td></td>
</tr>
<tr>
<td>060F02002</td>
<td>060F02003</td>
</tr>
<tr>
<td><strong>070A02002</strong></td>
<td>070B02002</td>
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<td>070A02003</td>
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<td>060A02003</td>
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<tr>
<td>070B02002</td>
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</tbody>
</table>
4 Curriculum activity blocks

Standards based curriculum design must consider Benchmarks in developing the building blocks of a curriculum or, what we have termed, Curriculum Activity Blocks or CABs. A CAB may range from a traditional classroom activity or unit to an individual or team project or problem, which is tied to one or more Benchmarks in one or more areas. CABs may be designed for the full range of learning development and a CAB may even be designed as a terminal Benchmark assessment tool.

New standards should bring a complete re-thinking of the CABs comprising an existing curriculum though all too often CABs get recycled with, at most, an inventory of the related benchmarks tagging each CAB. CABs are assembled to fit the constraints of the school day and school year. The process is depicted in Figures 3, 4 and 5 and more fully described in the AAAS publication, Designs for Science Literacy [8], which also documents decades of thinking on the matter. The process, which is termed, Design by Assembly, is likened to a two-dimensional CAD assembly of blocks that fit a given space. But, curricula based on Benchmarks such as those documented in Project 2061 will require much more than a mere assembly of CABs. The process is made complex by a series of factors:

1. The benchmarks are interrelated as discussed earlier.
2. The status of students with respect to benchmark accomplishment varies by student and changes with time.
3. There are often other constraints arising from teacher agreements and state and federal rules related to or affecting scheduling.
4. There is a tendency, in many school settings and in response to shortfalls in teacher preparation time, for teaching staff to re-cycle CABs, a kind of “bend to fit” approach rather than a creative re-thinking of CABs that meet intended benchmarks.
5. There is often an isolation with respect to communications between teachers of different grades.

Figure 3: Grades and days in a school year.
This is clearly a formidable task with the full range of complexities of the most sophisticated of problems. From a systems perspective a key component of curriculum design is understanding the problem, not just the dimensions noted in this paper but also the issues stemming from the culture of the school. Relating to an understanding of the problem are questions such as: Where are our students? What do we expect them to accomplish (the benchmarks)? How are the benchmarks related? What are the priorities? Are we focusing on broad literacy areas or specialized areas of learning? What are the time frames? What are the constraints? Are all of these imposed or can some of them be negotiated?

5 Tools

As the process moves to considering CABs that address the needs and to evaluating individual CABs and the curriculum as a whole, it is clear that tools are needed. Yet, while many visual organizers and software applications have emerged, much more will be required to fit this problem. In 2001, the author set out to create a wish list of functions that might be served by a tool or a suite of tools. Ultimately, the desired product would assemble a set of CABs, each addressing one or more benchmarks,
into a curriculum optimized to meet the benchmarks for every student under the constraints of the situation. [The problem can be formulated as a systems optimization problem with perhaps an evolutionary algorithmic approach, the subject of which will await another paper.] For purposes of this discussion, suffice it to say that some intermediate tools are required to meet the practical application of the aforementioned ideas. One of the suite of tools that has been developed and tested is TraxLiteracy[2]. TraxLiteracy supports benchmarks as these have been defined in this paper from state, national, association (such as AAAS Project 2061 and National Academy Foundation) and school sources. Benchmarks are expected to be accomplished at certain points in time and accomplishment of these is tracked for each student in the TraxLiteracy system. Figure 6 shows a partial menu frame for this system. Interested readers are encouraged to visit www.traxliteracy.com or contact the author.

From 2002 to present, thorough testing of the system has taken place at the Times2 Academy. A small set of the Academy’s Division 1 CABs supporting Project 2061 Benchmarks are shown in the following table.

Figure 6: Partial menu frame from TraxLiteracy.com
Notice that several CABs address several Benchmarks, yet there are Benchmarks which are not addressed by any CABs in this small subset. Work is in process to display the time-sequence of CABs in the curriculum and to overlay the implied order in which Benchmarks are undertaken and the prescribed order in which they are intended to be undertaken. This would facilitate the iteration of CAB development and sequencing that must be done to arrive at a workable curriculum that satisfies the constraints of time and order that must be met. The process is depicted in Figure 7 for a hypothetical and simple system of Benchmarks and CABs. Figure 7A shows CABs, X, Y and Z and the Benchmarks that each activity addresses. Figure 7B shows the hierarchy of the Benchmarks, BMs from left to right, 1 and 6 being the most fundamental ones; 5 and 3 require that 1 be completed and 4 and 3 require that 6 be completed; 2 requires 4 and 4 requires 3. This hierarchy suggests two BM sequence options and these are shown in Figure 7C. Finally, each CAB sequence results in a BM sequence shown in Figure 7D.

Each of the CAB-related BMs in the sequence is scored for purposes of illustration with a +1 for being in the right sequence and a -1 otherwise. It is clear from this simple analysis that CAB sequence XZY is the best choice for this hypothetical curriculum. It is also possible in a real situation involving an existing set of CABs addressing 50 or more BMs that no sequence will meet the requirement that all BMs be met in sequence. The practical consequence of this situation is that emphasis in curriculum design should be on CAB design around specific BMs versus a reliance on one’s inventory of existing learning activities to assemble a curriculum. Such an approach was suggested and formulated by Wiggins and McTighe [9], who used a design methodology approach that emphasized the framing of learning experiences, what we have termed CABs, as the final stage of the curriculum design process.
CABs | BMs addressed
---|---
X | 1-6-3
Y | 5-2
Z | 6-4

Figure 7A

BM Hierarchy

1 5
3
6 4 2
3 4

Figure 7B

Order based on Hierarchy
6-3-4-2 & 1-5-3
6-3-4-2 & 1-3-5

Figure 7C

<table>
<thead>
<tr>
<th>CAB Order</th>
<th>Implied BM Order</th>
<th>Score for BM Order</th>
<th>Total</th>
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<td>1 -1 1 1 1 1 1 1</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 7: A. CABs X,Y, and Z and the BMs each addresses; B. The hierarchy of BMs is from left to right (see text); C. BM sequencing options based on the BM hierarchy; D. Scoring for each CAB based on its BM sequence (see text).
6 Conclusions

This paper has outlined a systems view of curriculum design and management wherein curriculum is viewed as a time-varying configuration of learners and learning activities, or curriculum activity blocks (CABs), organized to accomplish a set of benchmarks, BMs. Benchmarks are learning outcomes, standards or goals to be achieved at certain times in the continuum of school years and are hierarchically ordered on a number of levels. TraxLiteracy, a web-centric tool for managing CABs and related BMs along with student progress and achievement, has been developed and tested at the TIMES² Academy, a charter school in Rhode Island, USA, that has adopted Project 2061 Benchmarks for its K-12 Science Literacy curriculum. The intrinsic complexity of designing curriculum around ordered benchmarks has been discussed and the need for developing tools and practices to aid teachers, administrators, school improvement teams, literacy coordinators has been emphasized. Finally, while this paper used illustrations based on K-12 Benchmarks, similar consideration needs to be given to post-secondary curricula as well. Certain literacy standards are normally assumed to have been met for students entering a college or university program but new course work is often built upon a set of interdependent learning objectives which must be recognized in developing the lessons and learning activities of university-level courses. This will become increasingly important as colleges and universities are held accountable for their teaching-learning practices and outcomes.

Acknowledgments

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References


