

Final Report

Investigating High School Biology Texts as Educative Curriculum Materials: Curriculum Review Process

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Executive Summary

We undertook a review of eight sets of high school biology curriculum materials with the goal of determining their potential for promoting teacher learning. We were interested in characterizing the materials according to our framework for educative curriculum materials, or materials that promote teacher learning as well as student learning (Ball & Cohen, 1996; Davis & Krajcik, 2005). Our framework presents design heuristics intended to guide the design of such materials (Davis & Krajcik, 2005). The design heuristics are organized around support for the development of teachers' subject matter knowledge (SMK), pedagogical content knowledge (PCK) for science topics, and PCK for scientific inquiry. The framework emphasizes the importance of providing both rationales for instructional decisions and implementation guidance for teachers.

Although the design heuristics were not developed with the intention of using them for curriculum evaluation, we operationalized them into a coding key. We then determined what sections of text to code for each set of materials; we decided to code roughly 50 pages of text having to do with ecology and roughly 50 pages of text having to do with evolution for each set of curriculum materials. While coding, we regularly calculated inter-rater reliability and tracked our growing collective understanding of the general coding procedure as well as specific rules of thumb that we could employ in determining how to code specific instances. After coding all 100 pages from each text, we wrote narratives describing each set of materials. We also engaged in quantitative analyses of the data.

The questions around which we oriented our quantitative analysis were:

Orienting Question 1: What are the strengths and weaknesses with regard to the type and amount of educative features *across* the eight sets of curriculum materials?

- 1a. What did each set of curriculum materials look like with regard to PCK for topics, PCK for inquiry, and SMK, and what were the most common categories across all eight sets of materials?
- 1b. What were the most common educative features across all eight sets of materials?
- 1c. How did the number of rationales compare with the number of implementation guidance supports across all eight sets of curriculum materials?

Orienting Question 2: What were the strengths and weaknesses with regard to the type and amount of educative features *within* each set of curriculum materials? How do the materials compare to one another?

- 2a. How do the curriculum materials compare with one another with regard to the total number of SMK supports coded within each set of materials?
- 2b. How do the curriculum materials compare with one another with regard to the total number of PCK supports coded within each set of materials?
- 2c. Overall, how do the curriculum materials compare with one another with regard to the total number of educative supports coded within each set of materials?
- 2d. Overall, how do the curriculum materials compare with one another with regards to the total number of different types of educative features coded within each set of materials?

Our quantitative analyses indicate the following:

- Support for PCK for topics was most prevalent in the materials, followed by SMK support. Least support was provided for PCK for scientific inquiry.
- The most common forms of support for PCK for topics involved alerting teachers to student "misconceptions" and, in about half of those cases, helping teachers think about how they might address the student ideas.
- Implementation guidance—guidance about how to use or adapt particular instructional approaches—was far more prevalent in the materials than were rationales for why particular instructional approaches might be productive.
- The curriculum materials were fairly consistent in the strength of their support for teachers' SMK; one set of materials (Kendall Hunt's *Human Approach*) provided notably less subject matter support than the other materials.
- Two sets of curriculum materials (*Human Approach* and EDC's *Insights*) were much stronger than the rest of the materials in their support for PCK. However, *Insights* provided more support for PCK for topics, while *Biology—A Human Approach* provided more support for PCK for inquiry.
- In general, these same two sets of curriculum materials (*A Human Approach* and *Insights*) stood above the rest of the materials in terms of the overall number of instances of educative features for teachers. They also ranked the highest for having the richest support for educative features, as measured by the total number of different kinds of educative features found in the materials.

Our narrative summaries indicate the following:

- The quantitative results should not be taken as the only indicator of the quality of the curriculum materials in terms of how educative they are for teachers. For example, the narratives clarify that several of the materials included suggestions to help the teacher address student "misconceptions", but the suggestions amounted to simply telling the students the correct scientific answer—an approach not likely to actually promote student learning.
- Some of the materials very clearly indicated where the educative features for teachers were located, while others (most notably, *A Human Approach*) did not. On the other hand, in *A Human Approach*, the educative features were integrated into other text for teachers, potentially making them more helpful to teachers than the stand-alone format adopted by some of the other texts.
- Most of the materials included extremely limited instances of the educative features (at the level of a single sentence). *Insights* stood out as an exception to this trend, with its rich and integrated educative features that occurred throughout the materials.

Our final results indicate that *Insights* and *Biology—A Human Approach* are the most educative curriculum materials evaluated in this study. We do not distinguish among the remaining six materials. We conclude this report by examining the role that educative curriculum materials may play within a learning environment designed to support teacher learning, and we discuss implications for the design of educative curriculum materials and implications for the refinement of the design heuristics used in this study.

Introduction

As conceptions of learning and education change, curriculum materials and instruction need to change accordingly. Over the last century, there have been dramatic advances in learning theory, and reform documents in the last two decades have called for changes in how teachers teach (Association for the Advancement of Science, [AAAS], 1993; National Research Council [NRC], 1996; 2000). However, textbooks and curriculum materials have tended to remain the same, reflecting outdated modes of education. This study analyzes existing curricular materials for teachers of high school biology from a modern perspective and suggests directions for change in such materials.

For much of the twentieth century, education has been based on the “traditional thesis that a newborn’s mind is a blank slate (*tabula rasa*) on which the record of experience is gradually impressed” (National Research Council [NRC], 2000, p.79). In this conception of learning, knowledge is seen as a body of facts and skills to be memorized and practiced. As Edelson (2001) states, “A common criticism of traditional approaches to education is that they lead to shallow understanding because of their emphasis on memorization and recitation of facts. As Whitehead pointed out more than 70 years ago, the focus on memorization leads to ‘inert knowledge’ that cannot be called upon when it is useful (Whitehead, 1929)” (p.356). This traditional view of education is compatible with behaviorism, which emphasizes drill and mastery of basic skills (Burton, Moore, & Magliaro, 1996).

In the early twentieth century, Piaget, Vygotsky, and Dewey challenged this traditional learning theory and proposed more active alternatives. These new conceptions of learning inspired the cognitive revolution in mid century (Miller, 2003, p.142). Cognitive science has evolved since the cognitive revolution (Bruer, n.d.), and more recently the learning sciences have begun to apply the principles of cognitive science (Northwestern University, 2006). Four major learning sciences ideas include 1) active construction, 2) situated learning, 3) social interactions, and 4) cognitive tools (Krajcik & Blumenfeld, in press). The concept of active construction is particularly relevant in this study. Active construction of knowledge entails that “teachers and materials do not reveal knowledge to learners; rather learners actively build knowledge as they explore the surrounding world, observe and interact with phenomena, take in new ideas, make connections between new and old ideas, and discuss and interact with others” (Krajcik & Blumenfeld, in press, p.649). This new perspective on learning and teaching provides opportunities for individuals to construct integrated and usable knowledge (Krajcik, Blumenfeld, Marx, & Soloway, 2000). It is worth noting that this conception of learning holds true for both students and teachers: “Our discussion of [teacher learning] is based on the assumption that what is known about learning applies to teachers as well as to their students” (NRC, 2000, p.190).

Scientific inquiry is an important component in this vision of education. The *National Science Education Standards* state that “inquiry into authentic questions generated from student experiences is the central strategy for teaching science” (NRC, 1996, Ch. 3). Inquiry involves engaging learners in authentic scientific practices such as asking scientific questions, experiencing phenomena by designing and conducting investigations, collecting and analyzing data, constructing explanations based on evidence, and sharing their findings with others (Krajcik et al., 2000). In these ways, learning environments focused on inquiry enable students to actively construct their knowledge of science by teaching for a deep understanding of science content and processes and emphasizing reasoning skills.

Teachers play a fundamental role in helping students learn science through inquiry (AAAS, 1993; Crawford, 2000, NRC, 1996). However, teaching science through inquiry is no easy task. Teachers need to learn new knowledge and instructional practices and overcome many obstacles (Marx, Blumenfeld, Krajcik, & Soloway, 1997). As a result, many teachers need support in teaching in more reform-oriented ways. To support teachers' learning, Ball and Cohen (1996) have called researchers to find ways to use curriculum materials to support not only students' learning about the subject matter but also teachers' learning about how to teach it. They argued that curriculum materials can support teacher learning by providing insight into curriculum developers' design decisions and support for teachers as co-constructors of the curriculum (Ball & Cohen, 1996; Remillard, 2000). Materials that support both teacher and student learning are called educative curriculum materials (Heaton, 2000; Davis & Krajcik, 2005).

Curriculum materials are an ideal vehicle for supporting teacher learning because they are embedded in the "grammar of schooling" (Tyack and Cuban, 1995). Even though there are several forms of professional development that can promote teacher learning (cf. Loucks-Horsley, Hewson, Love, & Stiles, 1998), embedding learning opportunities within curriculum materials may be particularly successful because such materials are intimately connected to teachers' daily work. Consequently, curriculum materials can situate teacher's learning in their own practice (Brown, Collins, & Duguid, 1989; Putnam & Borko, 2000) and provide ongoing forms of support (Collopy, 2003). In these ways, curriculum materials can serve a dual function by fostering the understanding of both students and teachers simultaneously (although at different levels and in different ways).

Recent literature in science education has examined the role that educative curriculum materials can play in helping teachers foster a classroom culture of inquiry (Schneider & Krajcik, 2002; Schneider, Krajcik, & Blumenfeld, 2005). In investigating the role of dual-use curriculum materials in shaping teaching' knowledge and practice, Schneider and Krajcik (2002) found that educative curriculum materials can support teachers' knowledge of subject matter by presenting it beyond a level of understanding required for students. They also found that educative curriculum materials can support teachers' pedagogical content knowledge (PCK), that is, knowledge of how best to teach content (Shulman, 1986). Curriculum materials can support PCK by helping teachers learn new ideas about students, expand their repertoire of instructional practices, and understand the rationales for the underlying pedagogy.

Despite Ball and Cohen's call for the design of educative curriculum materials nearly a decade ago, most curriculum materials still reflect a traditional teaching and learning orientation. Additionally, many curriculum materials and textbooks still lack support for teachers in teaching science content and inquiry to students (Kesidou & Roseman, 2002). Teacher editions of textbooks often provide instructional representations and activities for teachers to use with students. However, they often fail to provide guidance on effective implementation or adaptation of the activities or rationales for using these activities (Remillard, 2000).

These materials do not support teacher learning because they do not follow a key precept for newer conceptions of learning, that is, making thinking visible (Linn, Davis, & Eylon, 2004). Over thirty years ago, Lortie (1975) pointed out that students' "apprenticeship-of-observation" was insufficient in preparing students to be future teachers, because students "are not privy to the teacher's private intentions and personal reflections on classroom events... What students learn about teaching, then, is intuitive and imitative rather than explicit and analytical" (pp.61-62). In an analogous fashion, the pedagogical thinking of the curriculum designer is not made explicit to

the teacher in most curriculum materials. Thus, the teacher is positioned as a curriculum implementer—“intuitive and imitative”—rather than as an analytical co-constructor of curricula. In these ways, many curriculum materials still fail to support teachers in developing new knowledge, beliefs, and practices about how to teach science through inquiry.

To help describe the ways in which curriculum materials can be better designed to promote effective science teaching, Project 2061 (n.d.) has developed a set of research-based criteria to evaluate science curriculum materials and to inform the design of new materials. However, most of these criteria only describe in what ways materials and instruction can promote students’ learning. To address the design of materials to support teachers’ teaching, Davis and Krajcik (2005) developed a set of design heuristics for educative curriculum materials. These heuristics are informed by recommendations put forth by Ball and Cohen (1996) and Brown and Edelson (2005) as well as by the limited empirical work that has been conducted on this topic. In this study, these heuristics were adapted for use in our evaluation of eight textbooks for introductory high school biology to determine how educative the textbooks were for teachers. The methods for this study are described below

Methods

Coding Rubric: Process for Operationalizing the Design Heuristics

Davis and Krajcik (2005) put forth nine design heuristics that provide guidance for the design of educative curriculum materials. Educative curriculum materials are meant to promote teacher learning, in addition to student learning, by providing not only appropriate curriculum activities but also the reasoning why teachers might want to use particular activities and recommendations for their effective use. Davis and Krajcik organized their design heuristics into three groupings: supports for pedagogical content knowledge (PCK) for science topics, PCK for scientific inquiry, and subject matter knowledge (SMK). SMK and PCK correspond to the components of content knowledge for teachers that were characterized in Shulman's (1986) seminal work on teacher knowledge. The further division of PCK into science topics and scientific inquiry are more recent elaborations upon this concept. More specifically, in their paper, Davis and Krajcik characterized supports for PCK for science topics as helping teachers engage students with topic-specific scientific phenomena and instructional representations as well as supporting teachers in anticipating, understanding, and dealing with students' ideas about science. Additionally, they defined supports for PCK for scientific inquiry as helping teachers engage students in answering and asking questions, collecting and analyzing data, designing investigations, developing evidence-based explanations, and promoting scientific communication.

When the design heuristics were initially generated, the authors did not have in mind that they would be directly used for analyzing curriculum materials. In order to make the design heuristics more accessible for analyzing such materials, we had to make some modifications and additions in order to transform them into a practical tool for evaluation. Dr. Davis, Dr. Krajcik, and seven graduate students operationalized the heuristics for evaluation purposes. First, we broke up each heuristic into individual phrases and sentences that reflected a single idea. We then used numbers and letters to categorize each idea for ease of identification. We term these ideas "points"; design heuristic includes points 1A (not an educative feature), 1B, 1C, 1D, and 1E. Table 1 includes an example of how design heuristic 1 was reorganized according to this process.

Table 1: Reorganization of Design Heuristics by Point

Original Design Heuristic 1*	Operationalized Design Heuristic 1	Category
Curriculum materials should provide teachers with productive physical experiences that make phenomena accessible to students as well as rationales for why these experiences are scientifically and pedagogically appropriate.	1A. Curriculum materials should provide teachers with productive physical (and vicarious ¹) experiences that make phenomena accessible to students	Non-Educative Curriculum Feature
Curriculum materials should help teachers adapt and use these experiences with their students, for example by making recommendations about which experiments are important and feasible for students to conduct themselves and which might be more successful as demonstrations.	1B. as well as rationales for why these experiences are scientifically and pedagogically appropriate	Rationale
Curriculum materials should warn of potential pitfalls with specific physical experiences.	1C. Curriculum materials should help teachers adapt and use these experiences with their students, for example by making recommendations about which experiments are important and feasible for students to conduct themselves and which might be more successful as demonstrations.	Implementation Guidance
Curriculum materials should suggest and help teachers think about productive sequences for experiences.	1D. Curriculum materials should warn of potential pitfalls with specific physical experiences.	Implementation Guidance
	1E. Curriculum materials should suggest and help teachers think about productive sequences for experiences.	Implementation Guidance

*Paragraph structure modified for ease of comparison of formats of heuristics.

In their paper, Davis & Krajcik (2005) purposively designed each heuristic to include three specific components. For each heuristic, they incorporated guidance for instructional approaches to give teachers direction about what they should do during a lesson, rationales to help teachers understand the reason behind particular instructional approaches, and recommendations for effective use to help teachers use the instructional approaches in productive ways in their own teaching. To make this organization explicit within the design heuristics, we organized each point into one of these three categories. More specifically, we labeled points as non-educative curriculum features (e.g., instructional approaches), rationales, and implementation guidance (e.g., recommendations for effective use), as shown in Table 1 above.

We defined non-educative curriculum features as all the customary content of curriculum materials that does not lead to teacher learning beyond the activities themselves. These non-educative features include recommended instructional approaches such as suggestions for particular experiences, phenomena, and representations that teachers might use in their teaching and the steps to take to implement these activities. Other non-educative curriculum features include suggested driving questions and discussion questions, student answers to discussion questions, and factual and conceptual knowledge of science content that is not beyond the level required for student understanding. We expected all curriculum materials to include these baseline features and thus did not code for them. These features appeared in most of the design heuristics in order to provide context for the educative features that built off of them. For example, in design heuristic 1, the first point (1A) is a non-educative feature: “Curriculum

¹ In early stages of coding, we realized that textbooks often suggest “thought experiments” or other activities that deal with phenomena and experiences. Thus, we expanded this heuristic to include such vicarious experiences.

materials should provide teachers with productive physical (and vicarious) experiences that make phenomena accessible to students.”

Next we defined rationales as educative supports that spur teacher learning by presenting explicit justification for the inclusion of particular instructional approaches in the curriculum. These features are educative because they make visible the judgment of the curriculum developers, helping teachers “integrate their knowledge base and make connections between theory and practice” (Davis & Krajcik, 2005, p. 5). The second point (1B) in design heuristic 1 shows that one educative feature in curriculum materials is the integration of a rationale for using particular instructional approaches: For example, curriculum materials should include “rationales for why these experiences are scientifically and pedagogically appropriate.”

Finally, we defined supports related to implementation guidance as those that help the teacher learn to use particular instructional approaches and activities productively and to adapt them to suit the particular context of use. Such features “promote a teacher’s *pedagogical design capacity*” (Brown & Edelson, 2003, cited in Davis & Krajcik, 2005, p. 5). In design heuristic 1, the third point (1C) is an example of an implementation guidance educative feature: “Curriculum materials should help teachers adapt and use these experiences with their students, for example by making recommendations about which experiments are important and feasible for students to conduct themselves and which might be more successful as demonstrations.”

In organizing the design heuristics according to these three categories, we generated some additional points for heuristics 4 and 5 (e.g., 4D, 5B, 5C). These additions enabled us to increase congruence by ensuring that most of the design heuristics included educative features dealing with rationales and implementation guidance. With regard to other modifications to the original design heuristics, we classified some sentences in design heuristics 2 and 9 as examples of features rather than as independent features and thus did not give them a separate number and letter to identify them as points. Finally, we recognized that supports for SMK would not include implementation guidance because SMK does not refer to the process of teaching but rather to the content. Instead, we decided that it would be more applicable to code for a feature-level characteristic in our analysis for this particular design heuristic. More specifically, we decided to code for science background knowledge for the teacher only when the information exceeded the information required for student understanding. Appendix A includes a table of the operationalized design heuristics that we used to analyze the curriculum materials in this review.

Process of Determining What to Code

In this curriculum review process, we analyzed eight textbooks to determine how educative they were with regard to supporting teachers’ PCK for science topics, PCK for inquiry, and SMK, following the operationalized design heuristics described above and summarized in Appendix A. Table 2 includes the list of textbooks that were included in this analysis.

Table 2: List of Textbooks Included in Curriculum Review

	Publishers	Textbook Title
1-GCC	Glencoe	Biology: A Community Context
2-GEE	Glencoe	Biology: An Everyday Experience
3-GDL	Glencoe	Biology: Dynamics of Life
4-GLS	Glencoe	Biology: Living Systems
5-KHA	Kendall Hunt: BSCS	Biology: A Human Approach
6-KEA	Kendall Hunt: BSCS	Biology: An Ecological Approach
7-EDCI	EDC	Insights
8-PHB	Prentice Hall	Biology

In determining which sections of the textbook pertained to evolution and ecology, each coder previewed his or her textbook and identified the relevant sections to code. This process was fairly clear-cut for books that included units that were titled ecology or evolution; however, for textbooks that did not clearly label these topics, this process was less straightforward. To determine which topics should be included in the evolution and ecology sections, each coder shared with the group the topics that he or she thought were relevant, and the other seven coders provided feedback about what to include or exclude. Additionally, we decided not to include topics on genetics in the evolution section. After determining which topics in the textbook pertained to evolution and ecology, we then totaled the number of pages for each respective section. Table 3 includes the units, chapters, and lessons that were identified as relevant to the evolution and ecology sections as well as the total number of pages on each topic for each textbook.

Table 3: Identification of Relevant Sections for Analysis

	Evolution Section		Ecology Section	
	Location in Text	Total Pages	Location in Text	Total Pages
1-GCC	Unit 7	42	Units 1-3, 8	203
2-GEE	Chapters 3, 29	30	Chapters 30, 31	57
3-GDL	Chapters 14-17	100	Chapters 2-5	100
4-GLS	Chapters 12, 13, 16, 17	180	Chapters 27-30	118
5-KHA	Chapters 2, 3	85	Chapters 15, 16	53
6-KEA	Chapters 9-10, 20, 21	80	Chapters 1-3, 22-24	140
7-EDCI	Traits/Fates Lesson 10 What on earth? Lesson 5	32	What on earth? Lessons 1-4, 6-7	95
8-PHB	Chapters 15-18	101	Chapters 3-6	105

We then decided to determine a set number of pages to code for each section rather than code every page in each section. We made this decision because different textbooks contained varying numbers of pages in their evolution and ecology sections. Therefore, in order to deal with this variation and to have a more equal point of comparison among all the textbooks, we decided to code a set number of pages.

We decided how many pages to code in each section for each textbook by first calculating how many pages, on average, were in each section of each textbook. We calculated this average by totaling the number of pages from all the evolution and ecology sections (1524

pages) and dividing that number by eight (the total number of curriculum materials) and by two (the number of topics—evolution and ecology—to analyze in each textbook. This calculation resulted in an average of 95 pages per section per textbook. From this calculation, we decided that each coder would code 50% of the average number of pages per section per textbook, resulting in each primary coder analyzing approximately 50 pages in each section of his or her textbook, for a total number of around 100 pages coded for each textbook. We decided not to code one hundred percent of the average number of pages in each section because approximately half of the sections did not even contain that many pages. Therefore, by coding 50% of the average number of pages, most coders had enough pages to analyze. However, in the evolution sections of three of the textbooks (i.e., 1-GCC, 2-GEE, 7-EDCI), fewer than 50 pages were coded because these texts contained less than 50 pages on evolution in these texts.

Finally, we developed a procedure for deciding how to select which 50 pages to code in each section of each textbook. For sections that had fifty pages or less, individuals coded all the pages in that section. For sections with more than fifty pages, individuals selected approximately twenty pages near the beginning, twenty pages from the middle, and ten pages at the end of each section to include in their sample.

Process of Calculating Inter-rater Reliability

After deciding how many pages each coder would analyze, we developed a protocol for calculating inter-rater reliability. We designated one person as the primary coder and another person as the secondary coder for each set of materials. The primary coder coded 50 pages in each section (or the entire section if less than 50 pages per topic) for each topic in his or her particular textbook while the secondary coder only analyzed a subset of the coded materials. Each person served as a primary coder on one set of materials and as a secondary coder on another set of materials. Textbooks were rotated among all eight individuals so that individuals did not simply exchange materials with one another. We decided to use this system of rotation so that we could obtain overlapping inter-rater reliability among all eight coders rather than between pairs of coders. Table 4 shows how the materials were shared among all eight coders.

Table 4: List of Primary & Secondary Coders

	Primary coder	Secondary coder
1-GCC	A	B
2-GEE	B	C
7-EDCI	C	D
4-GLS	D	E
3-GDL	E	F
8-PHB	F	G
5-KHA	G	H
6-KEA	H	A

In determining inter-rater reliability, we decided to code each textbook in approximately 10-page chunks and to keep a separate spreadsheet for each chunk of text. We completed the coding in chunks to enable us to iteratively determine inter-rater reliability on subsets of the coded materials. We analyzed our first set of ten pages in the same room together so that as questions arose about how to code our materials, we could discuss our questions with one another. After coding our first ten pages of our primary materials, we exchanged our textbooks so that the secondary coders could analyze the same subset of pages.

After the primary and secondary coders had both analyzed the first chunk of pages, they met to calculate their estimates of inter-rater reliability by percent agreement and to discuss any differences in coding until all disputes were resolved. We decided that the secondary coder

needed to code a minimum of 20% of the materials and reach a “sufficiently high” inter-rater reliability with the primary coder on at least one 10-page section of materials. We defined a “sufficiently high” inter-rater reliability as reaching 80% agreement or higher on one 10-page chunk. Usually, we would have liked to achieve higher reliability but because of time limitations we selected a percentage that we thought we could realistically achieve given the constraints that we had. Given this protocol for inter-rater reliability, some secondary coders only had to code 20 pages before 80% agreement or higher was reached. In other cases, the secondary coder had to code additional 10-page chunks until adequate reliability was attained. Table 5 includes the percent agreements obtained for each round of coding for each textbook.

Table 5: Percent Agreements for Each Round of Coding for Inter-Rater Reliability

Publishers	Book Title	Rounds of Coding			
		#1	#2	#3	#4
1-GCC Glencoe	Biology: A Community Context	65%	92%		
2-GEE Glencoe	Biology: An Everyday Experience	57%	85%		
3-GDL Glencoe	Biology: Dynamics of Life	89%	83%		
4-GLS Glencoe	Biology: Living Systems	67%	86%		
5-KHA Kendall Hunt: BSCS	Biology: A Human Approach	32%	54%	83%	92%
6-KEA Kendall Hunt: BSCS	Biology: An Ecological Approach	92%	82%		
7-EDCI EDC	Insights	25%	16%	79%	96%
8-PHB Prentice Hall	Biology	83%	83%		

We calculated inter-rater reliability using a set procedure. First, we calculated percent agreement within each heuristic, resulting in nine different percentages. We calculated these percentages by totaling the number of instances of agreement for each point, dividing that number by the total number of instances that were coded between the primary and secondary coders (i.e., total number of instances of agreement and disagreement), and multiplying that number by 100 to obtain the percent agreement for each heuristic. If there were no instances of agreement within a particular point, then we calculated a percent agreement of 0%. An absence of codes within a given point by both coders was considered an instance of agreement. After percent agreements were calculated for each heuristic, we then averaged all nine percentages to obtain an overall percent agreement for the 10-page chunk of coded materials. These are the percentages that are reflected in Table 5. After inter-rater reliability was achieved, the primary coder analyzed the remaining pages in his or her sample. See Appendix B for an explanation of *Insights*' inter-rater reliability.²

Process of Developing a Shared Understanding of the Coding Procedure

Before coding the sections involved in this study, the project leaders and four of the graduate students conducted a practice round of coding on materials not included in the evolution and ecology sections. The materials were the introductory materials and 10 pages from the genetics unit from the *Insights* (7-EDCI) materials. Additionally, one project leader and all seven

² After later work on clarification of the codes, additional reliability analysis was conducted on *Insights in Biology*, achieving 96% inter-rater reliability on 10% of the data.

graduate students conducted another practice round of coding from a section (not on ecology or evolution) out of the *Glencoe: Everyday Experience* (2-GEE) textbook. In each of these cases, we coded the materials in the same room, discussed our coding decisions, and constructed a common understanding of the heuristics and the coding process.

During the entire coding process, we kept track of questions that we had in determining how to apply each point. This allowed us to discuss these questionable instances with other group members. These discussions took place via email, an on-line posting board, and face-to-face interactions. This enabled us to resolve ambiguity as a group in the application of points by generating clarifying coding rules. Some of these discussions occurred after some individuals had finished coding their sections; therefore, some coders had to go back to their materials and recode according to the new rules. Additionally, some of these discussions occurred after some coders had already completed their percent agreements. However, checks for inter-rater reliability were not repeated if 80% agreement had already been reached. Instead, the primary coder just recoded the materials themselves (if needed) to reflect the new coding decisions that were made by the group. (We decided not to have the secondary coder recode because we assumed that as group members further clarified their understanding of coding procedures, inter-rater reliability would have continued to increase.) In sum, these discussions enabled us to continue to develop a shared understanding of each point as a group and to increase consistency across all eight people in how we applied the points. Table 6 includes a list of clarifying rules that emerged from the coding process.

Table 6: Rules to Clarify Application of Points

Heuristic	Clarifying Rules
H1: Using Topic-Specific Phenomena	<ul style="list-style-type: none"> • Do not code overviews of lessons as rationales (1B) because they are typically at too high of a level to apply. • Do not code text as rationale (1B) if it can be replaced with “Purpose: This experience will allow students to...” unless the text provides additional information about why this is scientifically or pedagogically appropriate. • Coders can confer with one another to determine whether they consider a student activity to be a phenomenon/experience (1) versus a representation (2).
H2: Using Instructional Representations	<ul style="list-style-type: none"> • Representations include drawing and photos. • A representation can be a representation even if students build it. • Simply suggesting an additional activity to extend students’ learning doesn’t count as 2B. • “Pointers” that are positioned in the wraparound region that reference text passages (e.g. an explicit reference to an analogy used in the text) aren’t in themselves educative unless they provide additional insight into the text.
H3: Identifying and Dealing with Students’ Ideas	<ul style="list-style-type: none"> • Do not code 3B if materials just give teacher a list of questions to ask students • Do not code 3B if the materials simply list the desired student response(s) or the scientifically correct answer(s). • If you codes a 3C, then you must also code a 3B.
H4: Using Questions	<ul style="list-style-type: none"> • Do not code 4D if the materials just give the teacher a list of questions to ask students.
H8: Fostering Communication	<ul style="list-style-type: none"> • Do not code 8A if the materials simply give the teacher ideas/questions that they could ask during a class discussion.
H9: Developing Subject Matter Knowledge	<ul style="list-style-type: none"> • Do not code 9B is the materials merely provide a list of benchmarks or standards or a set of learning goals/objectives. • Do not code 9B if the materials provide a random list of facts or irrelevant factual knowledge that is NOT explicitly connected to topics within the curriculum materials. • When the SMK is ambiguous about whether it is beyond the level of student knowledge or not, make a judgment call about whether to code the text as 9B.
Other (for all points having to do with implementation guidance)	<ul style="list-style-type: none"> • Code for implementation guidance if the materials provide suggestions for how the teacher can adapt the idea for use in their classroom and/or when the materials help the teachers know how to best use the idea. • Do not code for implementation guidance if the text only gives the teacher additional activities that s/he could implement in their practice, without any additional support.

Process of Writing Narrative Summaries

We present the results of our study of curriculum materials in two formats: narratives and quantitative data. With regard to the narratives, we each wrote a brief narrative to capture the in-depth detail that could not be described with the numerical data alone. First, each primary coder included an introductory paragraph that highlighted the intended audience for the curriculum materials they reviewed, the general format of the teacher materials, and the common

headings/sections. Next individuals highlighted which design heuristics and points were the most common in the materials and how often they appeared within the ~100 pages that they coded. Additionally, each narrative included an in-depth description of these most common points for each set of curriculum materials. More specifically, for each point, primary coders included a brief description of what the most frequent example looked like and whether that example provided strong or weak evidence in support of the point. Individuals also selected a quote from the materials to typify the most frequent example for each common point and described where the examples typically appeared in the materials. Describing the most commonly coded points in depth enabled us to provide a rich description of what these educative features looked like in the materials, show if these features provided strong or weak support for teachers, and show if the features were consistently and explicitly placed within the materials.

Additionally, because time constraints did not enable us to quantitatively analyze the teacher versions of lab manuals that accompanied some of the curriculum materials, we decided instead to include a qualitative description of the teacher's lab manuals (if one was included), highlighting the educative features that were present (if any). We then perused the introductory materials to each textbook, looking for supports for teachers and describing what these supports looked like in the materials. Additionally, we recognized that the design heuristics that we used to analyze the materials did not entail an exhaustive list of educative features for teachers. Therefore, we included a brief description of any other educative features that we found in the materials for which we did not code (e.g., supports dealing with assessment, diverse learners). Finally, we included insights into places within the curriculum materials that we felt had the most immediate potential for the development of additional educative features.

Process of Ranking Curriculum Materials

In addition to completing these narratives, we analyzed our data quantitatively. As previously stated, we coded the textbooks in 10-page chunks and compiled these data in a table for both the evolution and ecology sections. Appendix C includes these tables, which show the number of educative features that were coded for each point of each heuristic within each set of curriculum materials.

In compiling the data, we realized that some coders had fewer than 50 pages to code in their evolution section. More specifically, the textbooks 1-GCC (Glencoe: *Biology—A Community Context*), 2-GEE (Glencoe: *Biology—An Everyday Experience*), and 7-EDCI (EDC: *Insights*) had 42, 30, and 32 pages devoted to evolution, respectively, and thus had fewer pages coded in the evolution section in comparison to the other materials. As a result, we had to proportionally scale up the number of instances of educative features in these materials, extrapolating linearly to 50 pages. We increased the number of instances to reflect what would have been found if we were able to code 50 pages so that we could compare these three materials, which had less than 100 total pages coded, with the rest of the materials that had 100 pages coded. Therefore, we actually coded a fewer number of educative features in the evolution sections in these three curriculum materials than what is reflected in the adjusted data. Appendix C includes the adjusted total number of instances of educative features for these three materials.

After compiling the number of instances of educative features coded for each set of curriculum materials, we then made different kinds of calculations to use for comparisons among the materials. These comparisons helped us address the following research questions:

Orienting Question 1: What are the strengths and weaknesses with regard to the type and amount of educative features *across* the eight sets of curriculum materials?

- 1a. What did each set of curriculum materials look like with regard to PCK for topics, PCK for inquiry, and SMK, and what were the most common categories across all eight sets of materials?
- 1b. What were the most common educative features across all eight sets of materials?
- 1c. How did the number of rationales compare with the number of implementation guidance supports across all eight sets of curriculum materials?

Orienting Question 2: What were the strengths and weaknesses with regard to the type and amount of educative features *within* each set of curriculum materials? How do the materials compare to one another?

- 2a. How do the curriculum materials compare with one another with regard to the total number of SMK supports coded within each set of materials?
- 2b. How do the curriculum materials compare with one another with regard to the total number of PCK supports coded within each set of materials?
- 2c. Overall, how do the curriculum materials compare with one another with regard to the total number of educative supports coded within each set of materials?
- 2d. Overall, how do the curriculum materials compare with one another with regard to the total number of different types of educative features coded within each set of materials?

These questions are explored in detail in the results section below.

Process of Ensuring Reliability of Results

We used a variety of methods to ensure the reliability of our results. First, for data analysis, we compiled all of the quantitative data into one spreadsheet and reformatted the narratives to create consistency across reports. To ensure reliability of this information, we emailed the summary spreadsheet and reformatted narratives to the coders and asked them to verify the accuracy of their data. The second coder also examined the narratives the primary coder wrote and had the opportunity to comment on the narratives. Minor revisions were made to the narratives, as needed, while no changes needed to be made to the summary spreadsheet. We then emailed the revised narratives to the coders for final approval, which was obtained in all cases. Second, with regard to the quantitative data, we spot-checked the numbers in the tables we had generated that addressed our research questions to ensure that they were consistent with the original data from the individual coders. Third, to further ensure reliability, Dr. Davis spot-checked each set of curriculum materials, in order to check for coder drift (and corrected as necessary). Finally, as a last procedure to ensure reliability, we sent the final version of this report to all coders and faculty leaders for final revisions

Results & Discussion

Findings from Quantitative Data

In viewing the rankings that are presented below, several important factors need to be considered. First, as mentioned above, some of the materials had less than 100 pages to code in the evolution and ecology sections. Thus, their numbers had to be scaled up to allow us to compare across materials. A second consideration in viewing the rankings of materials is that the quality of the instances of educative features that we coded varied widely. For example, some materials had many instances of one particular type of educative feature but most of these instances provided weak evidence in support of the heuristic. Therefore, even though some materials might have had many instances of certain types of features, such materials might be less effective as vectors of teacher learning than a textbook with fewer but richer instances of particular types of educative features. Consequently, even though the quantitative data provides a basis for comparison among materials, they should not be considered alone but instead need to be considered in light of the narratives, because the narratives provide a richness and depth of characterization that is not afforded by numbers alone. The final consideration in viewing the data below is that some textbooks may not be entirely consistent in their degree of educativeness across the entire sets of chapters in the textbook. For example, the evolution and ecology sections might be more or less educative than the rest of the topics in the textbook.

1. What are the strengths and weaknesses with regard to the type and amount of educative features *across* the eight sets of curriculum materials?

1a. What did each set of curriculum materials look like with regard to PCK for topics, PCK for inquiry, and SMK, and what were the most common categories across all eight sets of materials?

Each set of curriculum materials contained varying numbers of instances coded for PCK for topics (design heuristics 1-3), PCK for inquiry (design heuristics 4-8), and SMK (design heuristic 9). Table 7 shows the number of educative features by category for each set of materials. These results show that most of the materials (1-GCC, 3-GDL, 4-GLS, 5-KEA, and 8-PHB) tended to have similar numbers of supports for PCK for topics and SMK, with very few (if any) supports for PCK for inquiry. On the other hand, the other three sets of materials (2-GEE, 5-KHA, 7-EDCI) tended to have more supports for PCK for topics than any other category. However, two of these textbooks (2-GEE, 7-EDCI) had more SMK supports than supports for PCK for inquiry, in contrast to the 5-KHA textbook, which had fewer educative features for SMK than PCK for inquiry.

Table 7: Frequency of Educative Features Within PCK for Topics, PCK for Inquiry, and SMK

Textbook	Instances of PCK for Topics *	Instances of PCK for Inquiry *	Instances of SMK Supports *	Total Instances *
1-GCC (Community Context)	31	5	30	66
2-GEE (Everyday Experience)	55	3	25	83
3-GDL (Dynamics of Life)	20	0	19	39
4-GLS (Living Systems)	20	3	16	39
5-KHA (Human Approach)	60	40	7	107
6-KEA (Ecological Approach)	24	2	20	46
7-EDCI (Insights)	78	19	28	125
8-PHB (Biology)	30	0	38	68
Totals	319	72	183	574

* In a 100-page sample (with shorter sections adjusted).

In addition to showing how prevalent the three different kinds of supports were within the individual sets of materials, Table 7 shows the frequency of each category across all eight sets of textbooks. First, support for PCK for topics was the most common type of category in these materials (55%). Second, SMK was the next most common category (32%). The number of supports for SMK is particularly high considering that only one design heuristic corresponded to this category in comparison to PCK for topics and PCK for inquiry, which had three and five corresponding heuristics, respectively. Finally, PCK for inquiry was the least common category (13%). This percentage seems particularly low, considering that five heuristics corresponded to this category. These findings suggest that these textbooks, in general, need to provide more support for PCK for inquiry.

1b. What were the most common educative features across all eight sets of materials?

The total number of instances coded for each educative feature across all eight sets of materials is represented in Table 8. These results show that point 9B was by far the most common form of support (32%), which was SMK support for the teacher that provided scientific information beyond the level of understanding required for students. Points 3B and 3C were the second (17%) and third (10%) most common forms of support, respectively. These forms of support help the teacher identify (3B) and deal with (3C) students' likely ideas about science. The next several most common educative features included supports for teachers in using topic-specific scientific phenomena and instructional representations. More specifically, these supports provided the teacher with rationales for why certain phenomena (1B) and representations (2C) were scientifically and pedagogically appropriate as well as implementation guidance about how to use these phenomena (1C, 1D) and representations (2B) effectively in their practice. All of these points that have been described (except for the most common educative feature) pertain to the category of PCK for science topics. Finally, the remaining points in Table 8 that were somewhat common in the materials included teacher supports for engaging students in questions (4C) and productive communication (8A, 8B). These forms of support correspond to the category of PCK for inquiry. The remainder of the points were found five or fewer times in the materials and thus appeared infrequently across all eight sets of curriculum materials. These

findings suggest that more supports for PCK need to be embedded within materials, especially with regard to supporting teachers’ development of PCK for scientific inquiry.

Table 8: Frequency of Educative Features Across All 8 Sets of Curriculum Materials

Point	9B	3B	3C	2B	1B	2C	1D	1C	4C	8A	8B
Frequency	182	99	55	47	36	27	24	23	21	16	15

*1E, 3A, 4D, 4E, 5B, 5C, 5D, 5E, 6A, 6B, 7A, 7B, 7C, 9C appeared 5 or fewer times total.

1c. How did the number of rationales compare with the number of implementation guidance supports across all eight sets of curriculum materials?

The total number of rationales and implementation guidance supports within each heuristic that were coded across all eight sets of materials is represented in Table 9. These results show that heuristics 5, 6, and 7, which pertain to PCK for inquiry, were infrequently coded for both rationales and implementation guidance. The number of rationales found in the materials was similar to the number of supports for implementation guidance for heuristics 1 and 8. However, the materials tended to include more supports for implementation guidance than rationales for heuristic 2 and even more so for heuristics 3 and 9. In other words, the textbooks tended to provide guidance on *how* to use particular instructional approaches without providing the reason *why* these particular approaches were scientifically and pedagogically appropriate. These findings suggest that these textbooks, in general, need to provide more rationales for teachers to help them understand why particular instructional approaches are scientifically and pedagogically appropriate.

Table 9: Frequency of Rationales & Implementation Guidance Supports Within Each Heuristic Across All Eight Sets of Curriculum Materials

	DH1	DH2	DH3	DH4	DH5	DH6	DH7	DH8	DH9
Rationale Supports	39	27	5	21	4	2	0	16	1
Implementation Guidance Supports	47	47	154	4	3	4	3	15	192

2. What were the strengths and weaknesses with regard to the type and amount of educative features *within* each set of curriculum materials? How do the materials compare to one another?

To get a sense of how the materials compared with one another, we examined the strengths and weaknesses of each set of materials across three categories (i.e., SMK, PCK for science topics, and PCK for inquiry) and then ranked these materials according to each category. Rather than just ranking the textbooks with regard to their overall number of supports provided, we decided to examine how these materials ranked according to each of these three categories so that we could see if the materials tended to include primarily SMK support, which is perhaps a more common feature of traditional textbooks, or if materials tended to include a wide variety of supports. Finally, we examined the overall ranking of the materials by looking at the total number of educative features found in each textbook and by examining the total number of different types of educative features.

2a. How do the curriculum materials compare with one another with regard to the total number of SMK supports coded within each set of materials?

The rankings of each textbook according to the total number of SMK supports found in each set of curriculum materials for a 100-page sample are represented in Table 10. Even though there are no clear divisions between materials, the results show which materials tended to rank the highest in SMK support, that is, 8-PHB, 1-GCC, 7-EDCI, and 2-GEE. However, overall, most of the materials tended to provide frequent opportunities for teachers to extend their factual and conceptual knowledge beyond a level of understanding required for their students. The only exception to this trend is 5-KHA, which had very few instances of SMK support in the 100-page sample. These findings suggest that these textbooks, in general, tend to provide strong support for teachers' SMK.

Table 10: Ranking by Subject Matter Knowledge Supports

Textbook	Total Number of Instances (in 100 pgs)
8-PHB (Biology)	38
1-GCC (Community Context)	30
7-EDCI (Insights)	28
2-GEE (Everyday Experience)	25
6-KEA (Ecological Approach)	20
3-GDL (Dynamics of Life)	19
4-GLS (Living Systems)	16
5-KHA (Human Approach)	7

2b. How do the curriculum materials compare with one another with regard to the total number of PCK supports coded within each set of materials?

The textbook rankings according to the total number of PCK supports found in each 100-page sample are represented in Table 11. These results show that the top two curriculum materials are 5-KHA and 7-EDCI, with 2-GEE ranking in the mid-range. However, excluding these three textbooks, the majority of the curriculum materials tended to provide much lower levels of PCK support for teachers. Since the number of supports for PCK educative features was compiled from eight of the nine heuristics, we consider that this table should be weighed more heavily than Table 10 in determining the overall rankings of educativeness within these curriculum materials.

Table 11: Ranking by PCK Educative Features

Textbook	Total Number of Instances (in 100 pgs)
5-KHA (Human Approach)	100
7-EDCI (Insights)	97
2-GEE (Everyday Experience)	58
1-GCC (Community Context)	36
8-PHB (Biology)	30
6-KEA (Ecological Approach)	26
4-GLS (Living Systems)	23
3-GDL (Dynamics of Life)	20

To further capture the kinds of supports provided by these materials, we divided the total number of PCK supports into supports for PCK for science topics and PCK for inquiry. The textbook rankings according to supports for PCK for topics and PCK for inquiry are represented in Table 12 and 13, respectively. These results show that 7-EDCI and 5-KHA are the top two ranking materials for both kinds of PCK.

Table 12: Ranking by PCK for Topics

Textbook	Total # of Instances (in 100 pgs)
7-EDCI (Insights)	78
5-KHA (Human Approach)	60
2-GEE (Everyday Experience)	55
1-GCC (Community Context)	31
8-PHB (Biology)	30
6-KEA (Ecological Approach)	24
3-GDL (Dynamics of Life)	20
4-GLS (Living Systems)	20

Table 13: Ranking by PCK for Inquiry

Textbook	Total # of Instances (in 100 pgs)
5-KHA (Human Approach)	40
7-EDCI (Insights)	19
1-GCC (Community Context)	5
2-GEE (Everyday Experience)	3
4-GLS (Living Systems)	3
6-KEA (Ecological Approach)	2
3-GDL (Dynamics of Life)	0
8-PHB (Biology)	0

More specifically with regard to the ranking for PCK for science topics, 7-EDCI had the most supports for teachers with 5-KHA and 2-GEE following a close second and third, respectively. The remaining sets of curriculum materials provided less frequent support for PCK for science topics, that is, less support for teachers in using topic-level phenomena (heuristic 1), instructional representations (heuristic 2), and students’ ideas (heuristic 3).

With regard to the ranking for PCK for inquiry, 5-KHA secured the highest ranking with 7-EDCI following in second place. All other curriculum materials fared poorly by comparison in supports for PCK for inquiry, that is, they provided less support for teachers in engaging their students in answering and asking questions, collecting and analyzing data, designing investigations, developing evidence-based explanations, and promoting scientific communication. Overall, these findings suggest that some of the materials tended to provide more PCK support for teachers than other materials but that most of the textbooks provided very little support for PCK for scientific inquiry.

2c. Overall, how do the curriculum materials compare with one another with regard to the total number of educative supports coded within each set of materials?

The textbook rankings by the total number of educative supports found in each 100-page sample are represented in Table 14. These results show that 7-EDCI and 5-KHA were the top two ranking sets of curriculum materials. The textbooks that fell within the mid-range for overall teacher support included 2-GEE, 8-PHB, and 1-GCC. Finally, 6-KEA, 3-GDL, and 4-GLS ranked at the lower end for total number of educative features. These rankings for total number of educative features are comparable to the rankings for total number of PCK educative features. (In interpreting these results, we must remember the three considerations that were outlined at the beginning of this section, especially the idea that we had to proportionally scale up the total number of instances coded in the evolution section for 7-EDCI, 2-GEE, and 1-GCC because fewer than 50 pages on evolution were coded for these materials. Therefore, the total number of instances for these materials may be slightly higher or lower than what would have been found if 50 pages had been available to code.) Nonetheless, these rankings reflect the overall educativeness of these materials with regard to supports (e.g., rationales, implementation guidance) for SMK, PCK for topics, and PCK for inquiry.

More specifically with regard to the top ranking materials, the *Insights* materials provided strong support for both PCK and SMK. However, unlike the *Insights* materials, the *Biology—A Human Approach* curriculum mainly contained frequent supports for PCK, not SMK.

However, even though these two materials ranked high in comparison to the other materials, all eight textbooks tended to lack support for PCK for inquiry. In general, most of the textbooks needed to include more support for helping teachers engage their students in asking and answering scientifically oriented questions (heuristic 4) and in communicating in productive ways (heuristic 8). Additionally, all of these materials tended to have few supports for heuristics 5, 6, and 7, that is, supports for teachers to help them engage their students in collecting and analyzing data, designing investigations, and developing evidence-based explanations.

2d. Overall, how do the curriculum materials compare with one another with regard to the total number of different types of educative features coded within each set of materials?

The textbook rankings by the total number of different types of educative features found in each 100-page sample are represented in Table 15. These rankings reflect the overall richness of support for educative features. There were a total of 25 different kinds of educative features that could have been potentially coded for in this analysis (see Appendix A).

These results show that 5-KHA and 7-EDCI were again the top two ranking sets of curriculum materials. The rest of the textbook rankings were closely spaced and did not provide any clear divisions. The higher ranked materials presented support for many of the 25 points considered in this study, while lower ranked materials presented support for fewer different kinds of points.

However, even though 5-KHA and 7-EDCI ranked high in comparison to the other materials, these textbooks were not well balanced in the support that they provided. While Kendall Hunt: *Biology—A Human Approach* presented support for 18 different points, 78 out of the 107 instances of educative support that were coded pertained to only 6 different points. The remaining types of educative features had 5 or fewer instances coded in the 100-page sample. EDC: *Insights* presented a similar configuration: 97 out of the 126 instances of educative support

Table14: Ranking by Total Educative Features

Textbook	Instances of Educative Features (in 100 pgs)
7-EDCI (Insights)	125
5-KHA (Human Approach)	107
2-GEE (Everyday Experience)	83
8-PHB (Biology)	68
1-GCC (Community Context)	66
6-KEA (Ecological Approach)	46
4-GLS (Living Systems)	39
3-GDL (Dynamics of Life)	39

Table15: Ranking by Total Number of Points Coded

Textbook	Number of Heuristics Coded (in 100 pgs)
5-KHA (Human Approach)	18
7-EDCI (Insights)	16
1-GCC (Community Context)	12
4-GLS (Living Systems)	10
2-GEE (Everyday Experience)	9
6-KEA (Ecological Approach)	8
3-GDL (Dynamics of Life)	8
8-PHB (Biology)	7

coded in the materials pertained to only 6 different points, with 6 or fewer instances of support coded for the other points.

To complement these quantitative results, we turn next to the narratives describing each set of curriculum materials.

Narrative Summaries

I. Glencoe—Biology: A Community Context

This curriculum, *Biology: A Community Context*, is designed for introductory high school biology classes. It is a separate teachers' guide from the student materials. At the beginning of each unit, the goals and major concepts are listed, followed by a unit overview, and then the national standards and benchmarks addressed in the unit. Each unit is broken down into guided inquiries. Most guided inquiries contain the following elements: activity overview, advance preparation, materials, teacher background information, instructional notes, homework, answers to interpretations, answers to applications, and in some cases, answers to biopredictions, student options, and extension. After the guided inquiries, the units contain self-checks, conferences, extended inquiries, congress, forum, unit exam, and student objectives.

1. Description of Most Common Codes

In our evaluation of this set of curriculum materials for educative features for teachers, we found that the most common code was for point 9B (subject-matter support for teachers). This code appeared 28 times in the sample pages coded from the ecology and evolution sections. The next most common code was for point 1B (rationales for why particular experiences are appropriate), for which nine instances were coded. Codes for points 3B (helping teachers in identifying students' ideas about science) and 1C (helping teachers in adapting and using phenomena) each appeared seven times. Additionally, seven other points were coded less frequently. (Note that these curriculum materials contained only 42 pages in the evolution section.)

Point 1B: Provides Teacher with Rationales for Why Particular Experiences are Appropriate

- **DESCRIPTION:** The materials provided a rationale for certain recommended experiences.
- **EXAMPLES:** Embedded within the activity overview on pg. 48: “Studying composting can lead to understanding the relationship between biology and energy transfer in the environment. This activity also provides a solid example of how individuals can have a positive effect on the environment while decreasing the amount of waste.” An example found embedded within the instructional notes on pg. 53: “...goes well beyond, allowing your students to make comparisons with the larger, somewhat different system that has all the same components...” This was a rationale for an optional activity.
- **LOCATION:** There was no consistent or explicitly named location within the materials to look for the rationale. Rationales were sometimes embedded within a description of the activity, within the activity overview, or within the instructional notes.

Point 1C: Helps Teacher Adapt and Use Experiences

- **DESCRIPTION:** The materials provided options for some of the recommended experiences.
- **EXAMPLES:** Embedded within the instructional notes on pg. 135: “Finding creatures in the compost can be aided in several ways...” Listed under the title Student Options on pg. 44: “Students really do enjoy this activity. However, similar data can be collected...” In

this example, the materials provided options (or suggested adaptations) to a recommended activity.

- LOCATION: Most of the examples were embedded within the instructional notes section of the text.

Point 3B: Supports Teachers in Identifying Students' Ideas About Science

- DESCRIPTION: These curriculum materials occasionally pointed out student ideas (e.g., misconceptions), but usually did not provide strategies for how to deal with them. Nonetheless, the supports for teachers to help them identify students' misconceptions provided adequate evidence in support of this code.
- EXAMPLES: Embedded within an answer to an interpretation question on pg. 136: "...students will make food chains straight lines of energy transfer. In nature, these are most often really food webs, with lots of interconnections...". This example points out student ideas, which are not correct. Again, embedded within an answer to an application question on pg. 380: "...but students may arrive at the idea that the richness of an aquatic ecosystem...".
- LOCATION: These instances are found embedded within answers to Interpretations and answers to Applications.

Point 9B: Supports Teachers in the Development of Subject Matter Knowledge

- DESCRIPTION: The materials were rich in subject matter knowledge provided for the teacher.
- EXAMPLES: Typical examples are found embedded within the possible student answer to either Interpretation or Application questions. Example from pg. 142: "The second law states that randomness or disorder must always increase in the system or its surroundings. Some of the energy that drives the process will be converted to or remain as heat. Therefore processes such as photosynthesis or cellular respiration are never 100 percent efficient. In other words, much of the original energy in the sunlight striking a plant is lost as heat rather than being stored as chemical energy, and much of the original energy in the foods organisms consume is lost as heat rather than being converted to ATP energy." Less commonly, examples were found within the text, included in the section titled Teacher Background Information. Example from pg. 421: "A large portion of the food energy that is assimilated by organisms is lost as heat. This heat loss occurs because all energy conversions (e.g. those associated with metabolic processes and with work) are less than 100% efficient, in accordance with the Second Law of Thermodynamics."
- LOCATION: Each inquiry activity contained a section titled Teacher Background Information; however, the information found in these sections was occasionally not presented at a level that went beyond the level of understanding required by the students. Often the subject matter knowledge was embedded within possible student responses for Interpretation and Application questions. A note to this effect was included on pg. 45: "When the answer is given without brackets, it is a far more detailed answer than any student will ever provide. Consider these answers to be both a composite of many student answers and background information for teacher and students."

2. Description of Educative Features in Lab Manual

None included in the materials sent, but a lab manual was listed as a component of the materials on page 3 of the introduction.

3. Description of Educative Features in Introductory Materials

This 30-page introductory section provided background information on the development of the materials including rationale for the different components included in the units. There was a suggested productive sequence along with a rationale for teaching biology. The introduction included instructional strategies and rationales for inquiry and communication in the classroom.

Although these pages were not explicitly coded, there were many examples of educative features present. However, the current design heuristics did not account for these general educative features in these materials.

4. Other Educative Features Not Coded

On pg. 379 the materials provided a suggestion to reduce students' anxiety over data calculations. The current heuristics do not address this sort of feature, although it could be considered to be educative.

5. Potential for Additional Educative Features

Often embedded in the Instructional Notes section of the text were suggestions for carrying out the activities but no rationale was ever provided for why the teacher should do these activities. Therefore, embedding rationales within the materials would make these activities more educative. Additionally, there were a few instances within the Instructional Notes where the materials suggested having a class discussion but did not provide a rationale or reason to hold the discussion. The materials lacked guidance on how to lead class discussions. These materials could become more educative if rationales and pedagogical suggestions are included to help the teacher know how to hold class discussions. Finally, even though these materials contained supports to help teachers identify likely student ideas, it would be much more educative if these materials also provided suggestions on how to help teachers address students' misconceptions.

II. Glencoe—Biology: An Everyday Experience

Biology: An Everyday Approach is a comprehensive text-based biology curriculum including numerous resources that are intended for introductory high school biology classes. The wrap-around teacher's edition of the text includes an extended margin of notes directed at the teacher, organized around the corresponding pages of the student text. Common headings in these teacher notes include a Section Overview, Preparation, Objectives, Motivation, Concept Development, Misconceptions, Teaching, Reteaching, Assessment, Background Info, and others. Entries under each heading are brief, typically no more than a single paragraph.

1. Description of Most Common Codes

In our evaluation of this set of curriculum materials for educative features for teachers, we found that the most common code was for point 9B, or subject-matter support for teachers. This code appeared 21 times in the sample pages coded from the ecology and evolution sections. The next most common code was for point 2B, helping teachers adapt and use instructional representations, which appeared 10 times in the materials. Codes for points 1B, 3B, and 3C appeared eight times each. Other codes appeared with less frequency. (Note that these curriculum materials contained only 30 pages in the evolution section.)

Point 1B: Provides Teacher with Rationales for Why Particular Experiences are Appropriate

- **DESCRIPTION:** Most of the chapters offered some suggestions about experiences that teachers could provide for their students. However, even though the text contained several suggestions for additional student activities throughout each chapter, only a few of these suggestions included enough of a rationale to be considered educative.
- **EXAMPLE:** As an example, Chapter 30 (p. 633) suggests that teachers take their students out to a location where they can count members of both animal and plant communities in order to demonstrate how much more difficult it would be to count members of animal populations as compared to plants.

Point 2B: Helping Teachers Adapt and Use Instructional Representations

- **DESCRIPTION:** Supporting teachers' use of representations was the second most commonly coded point. These were usually sidebar comments in the wraparound teacher's guide that suggested ways to connect photos in text to topics related to the unit or pointed out salient aspects of particular representations.
- **COMMON EXAMPLES:** After suggesting that the teacher show some slides depicting populations of plants and animals in natural settings, the text explains that two or more interacting populations form a community (p 633).
- **LOCATION:** The most common entry typically occurred as a "Motivation" suggestion at the beginning of a lesson.

Point 3B: Supports Teachers in Identifying Students' Ideas About Science

- **DESCRIPTION:** These entries generally provided a statement of a student misconception and a single strategy for addressing these misunderstandings. This type of example provided adequate evidence in support of this code.

- **COMMON EXAMPLE:** On p. 631, the text explains that students often do not consider animals as important members of particular foodwebs, and notes that all communities play important roles in their foodwebs.
- **LOCATION:** The bulk of these sightings occurred in the Misconceptions entries in the wraparound section on the page where the topic was introduced.

Point 3C: Supports Teachers in Dealing with Students' Ideas About Science

- **DESCRIPTION:** This code appeared in connection with codes for point 3B. The usual strategy for dealing with students' ideas was to point out the right answer. This type of example provided weak evidence in support of this code.
- **COMMON EXAMPLE:** The example in 3B above shows a typical instance of a 3C code. The strategy suggested is simply noting that all communities play important roles in their foodwebs (p.631).
- **LOCATION:** These educative features occurred in the Misconceptions entries in the wraparound section on the page where the topic was introduced.

Point 9B: Supports Teachers in the Development of Subject Matter Knowledge

- **DESCRIPTION:** Point 9B was the most commonly coded point. The most common form of support for the teacher was providing additional information about the topic at hand, slightly beyond the student level.
- **COMMON EXAMPLES:** For example, one Science Background section lists factors limiting the size of plant populations (availability of sunlight and space). One Misconception points out how mushrooms absorb organic matter by secreting enzymes that break the matter down into nutrients (p. 639). Some similar sections providing additional information to teachers were not coded. In some cases, the information provided was not linked to the topics being developed. An example of this is the Science Background on p. 641, which states that shorter food chains are more efficient than longer food chains without explaining why that idea is important.
- **LOCATION:** This educative feature appeared in many different sections throughout the textbook, such as the Concept Development, Misconceptions, and Science Background sections.

2. Description of Educative Features in Lab Manual

The teacher's edition of the laboratory manual has answers to questions, tips for teachers in preparing solutions, and some additional background information pertaining to lab experiments. Other than this additional information, there was little, if anything, that qualified as educative under the heuristics employed in this study.

3. Description of Educative Features in Introductory Materials

The introductory material provided general guidance with planning, working in groups, etc. These entries were not generally referred to in the entries directed at the teacher in the wrap-around text, and consequently, were not coded as educative elements.

4. Other Educative Features Not Coded

None.

5. Potential for Additional Educative Features

The potential for this text to be "educative" for teachers is dubious given the space constraints of providing teacher support in the margins of the student text. Entries that were coded were often single sentences, and consequently represented weak examples of support for teachers' learning. Because the suggested activities, examples, etc., seemed extremely basic, a teacher with a deep background in biology would probably not find the educative elements very helpful, and the brief nature of the support entries limited their usefulness for teachers with weak subject matter knowledge.

III. Glencoe—Biology: Dynamics of Life

These materials are intended for introductory high school biology classes. The teacher materials for Biology: Dynamics of Life are presented in the form of a wraparound, with teacher materials surrounding a student textbook. Lessons in the teacher materials are structured around a format with the following headings: Revealing Misconceptions, Minilab, Problem Solving Lab, Inside Story, Concept Development, Enrichment, Resources, Inquiry, Reinforcement, and Assess. At the bottom of the teacher materials, activities are provided that allow the teacher to cater to other students in the class, such as those with learning disabilities or the more gifted students in the class. These have headings like Inclusion Strategies and Challenge Activity. Within some of these sections, there were subsections that were more detailed for the teacher, such as Purpose (of the activity), Process Skills, Chalkboard Example, and Teaching Strategies. These subsections do not appear only in the sections for diverse learners. They are also found in other parts of the text, like in Minilabs, for example.

1. Description of Most Common Codes

In our evaluation of this set of curriculum materials for educative features for teachers, we found that the most commonly coded point was 9B, or subject-matter support for teachers. This educative feature appeared 18 times in the sample pages coded from the ecology and evolution sections. The next most commonly coded points were 2B (helping teachers adapt and use instructional representations) and 3B (helping teachers identify students' ideas about science). Both appeared six times. Most of these educative features were found in the Ecology section. Other codes appeared infrequently.

Point 2B: Helping Teachers Adapt and Use Instructional Representations

- DESCRIPTION: The materials occasionally suggested activities that would be helpful for students to create representations of phenomena in science. Support in adapting and using those representations was provided, for instance, for learning disabled students.
- COMMON EXAMPLE: “Learning Disabled: have students use block diagrams on paper to model how the experiments of Redi or Pasteur demonstrate scientific methods. Have students record their procedure.” (p. 381)
- LOCATION: These were generally found at the bottom of the teacher material page, under the heading of Inclusion Strategy.

Point 3B: Supports Teachers in Identifying Students' Ideas About Science

- DESCRIPTION: The materials occasionally provided the teacher with possible student misconceptions, a 3B code.
- COMMON EXAMPLE: “Students sometimes think that fossils are rare when, in fact, fossils can be found nearly anywhere sedimentary rocks are exposed.” (p. 370.)
- LOCATION: These educative features were usually found in a section titled Reading Misconceptions.

Point 9B: Supports Teachers in the Development of Subject Matter Knowledge

- **DESCRIPTION:** The book frequently provided additional background information about the subject matter. There were times when the information was in good depth and detail, and other times it was barely above student level information.
- **COMMON EXAMPLE:** An example that provides weak evidence of point 9B is this Quick Demo: “Microscopic Life... Point out that early cyanobacteria are hypothesized to have produced most of the oxygen that changed the initial composition of Earth’s atmosphere.” (p. 377). Stronger evidence for this point was provided by this Cultural Diversity section: “Motonori Matuyama and Paleomagnetism. For unexplained reasons, Earth’s magnetic polarity has changed many times so that Earth’s north magnetic pole became Earth’s south magnetic pole or vice versa. The Japanese geologist Motonori Matuyama (1884-1958) first discovered these reversals. Because these polarity changes have been dated in volcanic rocks, the magnetic polarity of some sedimentary successions can be used to estimate the ages of the rock layers.”(p. 370) This second example provides the teacher with some history of the subject that is not evident in the text and is beyond the level of knowledge students are expected to master. It allows the teacher to better comprehend how fossils can be dated, providing evidence for evolutionary processes.
- **LOCATION:** These features were found at the bottom of the teacher material pages, in a variety of sections including Cultural Diversity and Quick Demo.

2. Description of Educative Features in Lab Manual

There was no lab manual for teachers.

3. Description of Educative Features in Introductory Materials

This textbook included a “chapter organizer” prior to each chapter, which set out the goals as well as materials required. It was meant to help in teacher planning but was not educative as defined by the heuristics.

4. Other Educative Features Not Coded

None.

5. Potential for Additional Educative Features

This set of curriculum materials provided rich support at the feature level, suggesting numerous activities and representations that teachers could use. However, it usually did not support the teacher by providing rationales or guidance for effective implementation or adaptation. Such educative features would greatly add to the effectiveness of these materials.

IV. Glencoe—Biology: Living Systems

These materials are intended for introductory high school biology classes. The teacher materials for *Biology: Living Systems* are in the form of wraparound text surrounding a student textbook, as well as teacher versions of lab manuals and extra booklets on concept maps and lesson planning. Sections called Prepare, Focus, Teach, and Assess provided objectives, key concepts, and activities for every section. Additional boxes or sections addressed topics such as meeting individual needs, misconceptions, cultural diversity, or different viewpoints in biology.

1. Description of Most Common Codes

In our evaluation of this set of curriculum materials for educative features for teachers, we found that the most commonly coded point was 9B, or subject-matter support for teachers. This code appeared 16 times in the sample pages coded from the ecology and evolution sections. The next most commonly coded point was 3B, which was support for helping teachers identify students' likely ideas about science. This code appeared seven times. The third most commonly coded point was 3C, which was support for helping teachers deal with students' likely ideas (6 instances coded). Additionally, 10 other codes appeared in the materials, in seven different categories.

Point 3B: Supports Teachers in Identifying Students' Ideas About Science

- **DESCRIPTION:** Identifying students' likely ideas was the second common code. The most common form was when the materials stated a common student misconception (3B). In around half of the cases, the materials also included the normative idea and encouraged the teacher to point it out to the students (a weak example of 3C).
- **COMMON EXAMPLE:** An example of a typical Misconception section is: "Some students will have the mistaken belief that all primates other than humans are more related to each other than to humans. Recent genetic studies have indicated that the chimpanzee and gorilla are more related to humans than to orangutans or other primates." (p. 318). There was no indication in the teacher materials of what ideas students tend to find difficult.
- **LOCATION:** These 3B educative features were found in the Misconception box, thus making explicit to teachers the purpose of the information. Not every section had such a box.

Point 3C: Supports Teachers in Dealing with Students' Ideas About Science

- **DESCRIPTION:** Supporting teachers in dealing with students' ideas about science was the third most commonly coded point. However, none of the instances suggested strategies to address these misconceptions, beyond "pointing out" the right answer (i.e., the 3C educative features were low level).
- **COMMON EXAMPLE.** See point 3B above for an example.
- **LOCATION.** These 3C educative features appeared following 3B features in the Misconception boxes, thus making explicit to teachers the purpose of the information.

Point 9B: Supports Teachers in the Development of Subject Matter Knowledge

- **DESCRIPTION:** Point 9B was the most commonly coded point. The most common form of support for the teacher was providing additional information about the topic at hand, slightly beyond the student level.
- **COMMON EXAMPLE:** For example, one Concept Development section discussed *Drosophila* species on the Hawaiian Islands, drawing an analogy to Darwin's finches on the Galapagos islands as organisms evolving to fill niches. One Cultural Diversity section talked about South American agriculture: "Six thousand years ago, pre-Incan Indians in South America were cultivating the common white potato. When they cultivated this plant, they practiced selective breeding to improve the quality of the potato from one generation to the next." (p. 314). Many similar sections providing additional information to teachers were not coded. In some cases, the information provided was not linked to the topics being developed. An example of this is the Earth Science Connection on p. 309, which discussed plate tectonics. Its only link to the topic of evolution was that "Scientists have discovered similarities in present-day organisms and in fossils between the Americas and Antarctica." A similar example was the Health Connection on p. 314, where methods of cockroach control were discussed. The only connection to evolution was that "Cockroaches have shown an intense power of resistance to many common insecticides. Some strains in Florida seem to be impossible to kill." (The way in which this resistance developed was not addressed.) Another common type of section provided information to teachers that was not beyond student level. An example is the Concept Development on p. 829, where information about succession in grasslands was provided. In the student materials, meanwhile, succession in tropical forests was discussed. Thus, the information provided was analogous to, and at a similar level as, the student material in the textbook.
- **LOCATION:** The instances of point 9B were interspersed among eight different sections, most commonly found in the sections on Concept Development, Different Viewpoints, and Cultural Diversity, but also in sections like Thinking Lab or Teaching Strategies. Thus, these supports were only occasionally explicit to the teacher.

2. Description of Educative Features in Lab Manual

The lab manual "Investigating Living Systems" consisted of the student manual, with answers and added information for teachers in red. There were several investigations per topic, more than what typically can be done in a school year (82). However, there was no guidance for deciding which to select. General strategies were provided for adapting experiments for class periods of different lengths (omitting parts, running fewer trials), but there was no discussion of the effects these modifications may have on learning. There was no discussion of why the experiments were scientifically or pedagogically appropriate beyond linking these to the content in the textbook. Pitfalls were pointed out, both in general sections about lab safety and living organisms, and for each lab, specifically.

The lab activities did not allow for students to design their own investigations. The materials also did not help the teacher think about how best to aid the students in writing evidence-based explanations or organizing and analyzing data. Instead, in "Investigating Living Systems", students' analysis involved responding to Analysis questions, for which answers were provided to the teacher.

The lab manual “Probing Levels of Life” was quite similar to the manual discussed above. Student answers were in response to a “Formulating Generalizations” section. However, teachers received no information from the manual on how to guide students in writing evidence-based explanations.

In neither lab manual was the importance of inquiry mentioned, and the experiments were not really inquiry activities.

3. Description of Educative Features in Introductory Materials

The introduction to the teacher’s edition had sections on cooperative learning and meeting individual needs. These sections explained the reasons for grouping and aided the teacher in thinking about how to approach learners with diverse needs.

A booklet on concept mapping provided next to no guidance to the teacher about the appropriateness of concept mapping, presenting this activity as a way to “reinforce and extend the graphic organizational skills” (p. 1) of the student.

A booklet entitled “Lesson Plans” provided lists of activities and sections from the textbook to check off as they were covered, along with suggested assessment and homework activities also from the book. There was no guidance for the teacher regarding the rationale or sequence of activities.

4. Other Educative Features Not Coded

Nothing else.

5. Potential for Additional Educative Features

The wraparound format of the teacher materials limited the space that could be devoted to additional educative features for teachers. Since the present wraparound text was not rich in educative features, a possible strategy might be to change the format to a separate teacher’s manual keyed to – but independent of – the student textbook.

The materials could benefit from inclusion of research-based strategies to address student misconceptions in general, along with suggested strategies to address these misconceptions that go beyond pointing out or stressing the normative viewpoint. The lab manuals would benefit from the addition of a section aligned to current standards, which stresses the importance of inquiry as a central strategy in teaching science. Guidance to the teacher about how to gradually relinquish control over the design of laboratory investigations, along with modifications to the student lab manual to go along with this approach, would greatly benefit the curriculum materials. In this way, this section of the teacher’s lab manual could easily address several of the design heuristics.

While the teacher textbook did include many instances of support for subject matter knowledge, most often the information provided it at a level just slightly above the student’s required level of understanding. Revising these instances so that they help the teacher develop a deeper conceptual understanding of the topic would also improve the materials.

V. Kendall Hunt: BSCS—Biology: A Human Approach

The *BSCS Biology: A Human Approach* curriculum is created for first-year high school biology students. It integrates the major concepts of biology into a human context by making connections among biology, daily life, and the human body. According to the developers, the curriculum incorporates an inquiry-based approach to learning biology by engaging students in asking questions, collecting data, and solving problems and by centering instruction around hands-on activities.

The curriculum's teacher materials are presented in the form of a teacher's guide. The student materials are found in a separate book. The only overlaps between the student and teacher materials are the lesson procedures (e.g., steps to take) and student questions. Additionally, lessons in the teacher materials were structured around a similar format with the following headings: major concepts, overview, materials, outcomes and indicators of success, preparation, process and procedures, and analysis. Sometimes extensions, background, further challenges, and safety were also included as lesson headings.

1. Description of Most Common Codes

In our evaluation of this set of curriculum materials for educative features for teachers, we found that the most commonly coded point was 3B, which was support for helping teachers identify students' likely ideas about science. This code appeared 28 times in the sample pages coded from the ecology and evolution sections. The second most commonly coded points included 3C, which was support for helping teachers deal with students' likely ideas (13 instances coded); 4C, which provided teachers with rationales for asking certain questions (11 instances coded); 8A, which provided teachers with suggestions for how to promote productive communication (9 instances coded); and 8B, which gave teachers rationales for why they should use particular approaches for promoting communication (10 instances coded). Additionally, thirteen other codes appeared in the materials but less frequently.

Point 3B: Supports Teachers in Identifying Students' Ideas About Science

- **DESCRIPTION:** The materials were rich with supports for helping teachers identify students' likely ideas about science. The most common example of this educative feature was when the materials told the teacher which concepts students would likely struggle to understand and in what ways. This type of example provided strong evidence for this code.
- **COMMON EXAMPLE:** "Students may not have recognized interdependence as a unifying principle shared by living organisms" (p. 547).
- **LOCATION:** These educative features appeared most often in the Process and Procedures sections and the Analysis sections. However, there were no special markings in the text to make these supports explicit to the teacher and there was no recognizable pattern as to when they would appear in the text.

Point 3C: Supports Teachers in Dealing with Students' Ideas About Science

- **DESCRIPTION:** In addition to helping teachers identify students' likely ideas, the materials sometimes followed up with strategies for teachers to help them deal with their students' ideas. The most common example of this support was giving the teacher

specific questions or ideas that he or she could use to guide his or her students' thinking. These examples provided strong support for this code.

- COMMON EXAMPLES: "If students point to the ability of an organism to use energy to move, ask them if this characteristic also applies to cars and other motor vehicles" (p.107). "Even if students express misconceptions about species or other concepts, do not correct their errors outright. Instead, guide them toward a more accurate and complete understanding by asking questions such as, How do you know? How can you be sure? or How might you test your idea? You also might suggest that the students review the essay if they appear to have problems with the concepts of species and diversity" (p.134).
- LOCATION: These educative features appeared most often in the Process and Procedures sections and the Analysis sections. However, there were no special markings in the text to make these supports explicit to the teacher and there was no recognizable pattern as to when they would appear in the text.

Point 4C: Provides Teachers with Rationales for Why Certain Questions are Appropriate.

- DESCRIPTION: Periodically throughout the evolution and ecology sections, the materials would provide a rationale for why a particular question was important for teachers to ask students. A common example of this support was giving a rationale that explained how a particular question could help the teacher during the lesson. Another common example of this feature included rationales that explained how a specific question could help promote students' learning. Both of these types of examples provided strong evidence for this code.
- COMMON EXAMPLES: "Answers to this question will provide an opportunity to informally assess the students' understanding of those concepts" (p.547). "This question encourages the students to think about their own notions of time and the relative occurrence of events" (p.68).
- LOCATION: These educative features appeared most often in the Process and Procedures sections and the Analysis sections. However, there were no special markings in the text to make these supports explicit to the teacher and there was no recognizable pattern as to when they would appear in the text. Additionally, these rationales appeared infrequently (overall) in the textbook, considering how many questions total that were asked in both units.

Point 8A: Provides Teacher with Suggestions for How to Foster Productive Communication.

- DESCRIPTION: In the materials, there were sometimes suggestions for how the teacher could promote productive communication in his or her classroom. The most frequent example of this educative feature entailed giving the teacher one vague suggestion of how to scaffold students' communication. This common example provided limited support for the teacher and thus provided weak evidence for this code. However, in one or two instances, the materials provided detailed support for the teacher to help him or her foster productive communication in the classroom. This less common example provided strong evidence for this code.
- COMMON EXAMPLE: "Make sure that everyone participates and considers all opinions, even contradictory ones" (p.136). This example draws the teacher's attention to how they might foster a productive discussion but does not provide explicit details of how to make this happen.

- RARE EXAMPLE: “Allow each team to present its position to the class without interruption before opening the floor to questions and comments. Encourage students to ask challenging questions phrased from the perspectives of their roles. If the debate does not begin without your help, assume a role yourself and demonstrate the type of questioning or criticisms you would like the students to provide” (p.582).
- LOCATION: These educative features appeared most often in the Process and Procedures sections. However, there were no special markings in the text to make these supports explicit to the teacher and there were no recognizable patterns as to when they would appear in the text.

Point 8B: Provides Rationales for Using Specific Approaches for Promoting Communication

- DESCRIPTION: Periodically, the materials provided rationales for why certain communication approaches should be used. The most common example of this educative feature provided rationales that explained how the communication approach could benefit students. This type of example provided adequate evidence for this code. Interestingly, however, very few of these examples followed any of the suggested strategies in point 8A.
- COMMON EXAMPLE: “This strategy will ensure that the students convey their information to their teammates and that they are able to learn from each other” (p.73).
- LOCATION: These educative features appeared most often in the Process and Procedures sections. However, there were no special markings in the text to make these supports explicit to the teacher and there were no recognizable patterns as to when they would appear in the text.

2. Description of Educative Features in Lab Manual

The materials had no lab manual.

3. Description of Educative Features in Introductory Materials

In the introductory materials to the textbook, there was a section on cooperative learning. It described the roles that students and teachers take in this approach and the reasons why the teacher might use this approach to foster productive communication. For example, it explained that cooperative learning motivates and empowers learners, decreases students’ dependence on the teacher, and increases students’ responsibility for their own learning. The Teacher Resource CD also included a section on how to help teachers use cooperative learning in their classroom. This section provides support for point 8A/8B.

4. Other Educative Features Not Coded

The lesson overviews provided the teacher with information about what students would be doing during the lesson and included a rationale for why the teacher and students should engage in these activities. These rationales tended to explain that the lesson activities would help students achieve the learning goals. For example, “This activity is designed to help students recognize the fundamental characteristics that are shared by all living organisms and to see that a description of these characteristics is, in fact, a description of life. Students also should see that

the unifying principles provide criteria by which we can recognize life, even in unusual forms and conditions. The learners explore these ideas through a study of the experiments of 1976, 1997, and 2004 that were designed to search for evidence of life on mars” (p.106). Therefore, some educative elements were included in the lesson overviews because a rationale was provided for why teachers and students should engage in the activities in the lesson.

5. Potential for Additional Educative Features

Most of the educative elements in the materials tended to be in the Process and Procedures sections and the Analysis sections. Therefore, more educative features could be incorporated into other sections in the materials or other sections could be added to the materials to enable additional educative features to be incorporated. Additionally, of the educative features that were present, there were no special markings in the text to make these supports explicit to the teacher and there were no recognizable patterns as to when they would appear in the text. Therefore, the educative features may need to be made more explicit to the teacher and be incorporated more consistently in the materials.

VI: Kendall Hunt: BSCS—Biology: An Ecological Approach

The BSCS Biology: An Ecological Approach curriculum is designed for first-year high school biology students and integrates the major concepts of biology into an ecological framework. According to the developers, the curriculum is centered around a student-centered, active-learning approach to learning science and offers a rich array of hands-on activities and laboratories that develop inquiry skills and conceptual understanding. The teacher’s textbook consists of a student textbook with some additional text in boldface print at the margins. There is usually very little additional text for teachers; on some pages, there is none (e.g., pp. 9 and 10). These additional comments are usually untitled. There is also a section in the front of the textbook directed to teachers that is slightly over 100 pages long.

1. Description of Most Common Codes

In our evaluation of this set of curriculum materials for educative features for teachers, we found that the most commonly coded point was 9B, or subject-matter support for teachers, with 20 instances coded in the sample pages from the ecology and evolution sections. The two second most commonly coded points were 3B, with 7 instances coded for explication of potential or probable students’ ideas, and 1B, with 10 instances coded for rationales for specific activities designed to promote student learning. There were also five additional codes that were found on one or two occasions.

Point 1B: Provides Teacher with Rationales for Why Particular Experiences are Appropriate

- **DESCRIPTION:** Occasionally, the materials provided rationales for why particular experiences were pedagogically and scientifically appropriate, especially with respect to stated learning objective and more student-centered, constructivist pedagogy. More specifically, they generally provided a rationale that related the specific concepts that were targeted by the experience back to the learning goals.
- **COMMON EXAMPLE:** “This investigation allows students to analyze and interpret some data concerning human cultures of the past. The investigation is quite open-ended, encouraging hypothesis formulation, challenge, and defense. Divergent responses to the questions afford many chances for discussion and evaluation of creative ideas and opinions” (p. 620).
- **LOCATION:** This particular support was found in the margins in the teacher’s materials, exclusively within the sections that dealt with specific investigations/activities/labs.

Point 3B: Supports Teachers in Identifying Students’ Ideas About Science

- **DESCRIPTION:** In some cases, the materials provided the teacher with specific examples of ideas students might have about a topic being addressed. Examples in the materials tended to provide strong evidence for this code.
- **COMMON EXAMPLES:** “To most students, the wolf and the coyote look alike” (p. 269). “Students may wonder if further collecting would turn up intergrades” (p. 260). “When discussing views of population growth, many students may think technology will maintain the quality of life; others will suggest that overcrowding uses too many resources (including privacy) and produces too much pollution to provide a high quality of life” (p. T105).

- LOCATION: These supports were found in the outer margins of the teacher's text but were found in various places.

Point 9B: Supports Teachers in the Development of Subject Matter Knowledge

- DESCRIPTION: The subject-matter supports were all short summaries of additional subject matter related to a particular concept addressed in the textbook. These features appeared to be designed to give teachers additional information with which to more easily illustrate given concepts and relate them to students' real-life experiences.
- COMMON EXAMPLE: "Although macroscopic organisms are classified primarily on the basis of structural characteristics, behavioral and biochemical data increasingly are being used in taxonomic determinations. Biochemical data are important in plant species determination, as well as in some groups of lichens. Biochemical data also are used in determining species of bacteria" (p. 267).
- LOCATION: The materials provided subject-matter supports for teachers in the form of teacher info boxes in the outer margins of the teacher edition of the textbook.

2. Description of Educative Features in Lab Manual

No lab manual was included.

3. Description of Educative Features in Introductory Materials

The teacher materials in the introductory section of the teacher textbook did not include educative features that would fall within the heuristics used for this study.

4. Other Educative Features Not Coded

There was one additional feature of the curriculum, which was educative but did not fall under any of the nine heuristics. The text offered some insight into using the text itself. This is interesting because as more and more educative features are added, the complexity of curriculum materials will indeed grow. Teachers may well need orienting guidelines for their own use of such resources in addition to guidance with respect to classroom practice.

5. Potential for Additional Educative Features

In many cases where educative elements were found, there was lost opportunity to make them more useful. For example, while the text did provide some examples of students' likely ideas (3B), it rarely gave any guidance on how to address them (3C). Additionally, even when additional content was provided (9B), it was unclear as to how and why teachers might draw upon this to enrich students' learning experiences. There is definitely space in the teacher's text for additional educative features.

VII. EDC: Insights

The *Insights* materials are designed for introductory high school biology classes. The materials include a lengthy, in-depth teacher's guide that supplements the student materials. Headings in the teacher materials at the beginning of each learning experience include learning objectives, overview, advance preparation, assumptions of prior knowledge and skills, and teaching sequence preview. This is typically followed by sections called Setting the Context, Experimenting and Investigating, Processing for Meaning, and Applying. Educative elements were most often found in set-apart boxes with titles like Science Background, Teaching Strategy, and Things to Watch For.

1. Description of Most Common Codes

We found that the most commonly coded point across the ecology and evolution units was 9B (support for the development of teachers' subject matter knowledge). This code occurred 20 times in the pages coded for ecology and evolution. The second most commonly coded point was 3B (support for helping teachers identify students' likely ideas about science), for which 17 instances were coded. The third most commonly coded point was 2B (helping teachers adapt and use instructional representations), for which 9 instances were coded. In all, 16 points were coded at least once in the teacher materials. In general, the educative elements included in *Insights* were at a high level. They were substantive, in depth, and potentially very helpful for teachers. (Note that these curriculum materials contained only 32 pages in the evolution section.)

Point 2B: Helping Teachers Adapt and Use Instructional Representations

- **DESCRIPTION:** When the activities to be completed involved using instructional representations, the *Insights* materials were very likely to support the teacher in knowing how to adapt and use those representations.
- **COMMON EXAMPLE:** A teaching strategy box on page 69 of *What On Earth?* provides a lengthy description of the ways in which a sliced and peeled apple can be used to help students visualize the percentage of the earth's surface that can support human life; the paragraph points out the salient features of the representation and helps the teacher know how to best use the representation. A box focused on embedded assessment on page 60 of *What On Earth* lists the salient features that student-generated representations of biotic relationships should include.
- **LOCATION:** These educative features appeared most often in the teaching strategy boxes. However, they were also located in other places in the text. Of course, these 2B codes were only applicable in instances where the activity itself involved an instructional representation of some sort.

Point 3B: Supports Teachers in Identifying Students' Ideas About Science

- **DESCRIPTION:** The materials provided numerous supports for identifying students' likely ideas. (Note: Although point 3C was not identified as a most-commonly coded point, it did occur in 8 instances in the coded pages, and the *Insights* materials seemed more likely than some of the other materials reviewed to provide helpful, substantive suggestions for how a teacher might address the alternative ideas identified.)

- COMMON EXAMPLE: In a teaching strategy box: “Pilot and field test teachers noted strong prejudicial attitudes when students discussed population dynamics...” (p. 69, *What On Earth*) or “Be alert to student responses that are anthropomorphic...” (p. 151, *Traits and Fates*). In the italicized text following a discussion question: “Students may not be able to respond to this question [about a real-world example of evolution not involving change from simple to complex]” (p. 149, *Traits and Fates*).
- LOCATION: These educative features appeared most often in separate teaching strategy boxes, in the italicized responses to recommended discussion questions, or in science background boxes. Note that lists of possible ideas that were all scientifically normative were not coded as instances of point 3B; the *Insights* materials often provided such lists (as italicized text following recommended discussion questions), which can indeed be very helpful for teachers.

Point 9B: Supports Teachers in the Development of Subject Matter Knowledge

- DESCRIPTION: The most commonly identified code in *Insights* was for point 9B, for supporting the development of a teacher’s subject matter knowledge. This code was especially prevalent in the evolution materials—14 of the 20 coded instances were in the evolution materials, despite there being fewer pages coded for the evolution materials.
- COMMON EXAMPLE: Two forms of subject matter support were common. In the evolution materials, especially, the science background boxes provided “pure” science knowledge—for example, there is a two-paragraph elaboration of the ways in which the discovery of metal in craters in various locations provide evidence that helps answer questions about the cause of the extinction of the dinosaurs (see p. 83-84 of *What On Earth*). Another typical approach illustrates how integrated the educative elements of the *Insights* materials often are. These forms of subject matter support typically started with the identification of a typical student misconception (point 3B), elaborated on the normative science perspective on that idea (point 9B), and then provided substantive suggestions for how a teacher could address the student misconception (point 3C); the science background box on page 81 of *What On Earth* provides an example.
- LOCATION: These subject matter supports appeared most often in the boxes labeled “science background”. However, occasionally we identified subject matter support elsewhere in the text.

2. Description of Educative Features in Lab Manual

There is no separate lab manual.

3. Description of Educative Features in Introductory Materials

The introductory materials were lengthy and potentially very helpful for teachers. The intro materials for *What On Earth?* and *Traits and Fates* were similar, though not identical. For example, the *What On Earth?* materials included sections on philosophy and goals, design of curriculum, teaching/learning frameworks, science thinking and process skills framework, assessment framework, organization of the teacher guide, special features of the module, the student manual, the student notebook, the classroom as a community, cooperative learning groups, concept mapping, models, technology tools, discussion, inquiry, critical thinking,

classroom safety rules, and overview of the module (including purpose, outcomes, and assumptions of prior knowledge and skills). Each of these many sections have the potential for being educative for teachers, both for areas our heuristics accounted for (e.g., fostering communication) and those outside of the scope of our analysis (e.g., the use of technology in science classrooms).

In addition, there was a separate “implementation guide” that provided a great deal of useful information, including guidance about the sequence of the modules and about fostering productive communication in a science classroom.

4. Other Educative Features Not Coded

Throughout the *Insights* materials, helpful overviews were provided. These were sometimes the overviews for the whole learning experience (and were labeled as overviews) but also appeared in much smaller grain sizes, on down to one-sentence overviews of the point of a homework assignment. The overviews for the learning experiences tended to provide a summary of what students would do and what they would learn, perhaps after a short introduction to the major content to be covered in the learning experience.

In addition, the materials had numerous pointers, in the margins, back to pages from the introductory materials. As noted above, the introductory materials were very thorough and helpful. We did not code these brief pointers as educative because they provided general information outside of the context of the lesson itself. However, we found the text alluded to by the pointers to be helpful and potentially educative in a more general sense.

Finally, several coded sections had instances of potentially educative aspects that were not covered by the scope of our heuristics. For example, the materials provided helpful “module connections” information that might help a teacher link to concepts and activities from previous units. The materials also tended to provide useful additional information about assessment—again, something that was outside of the scope of our coding. A third example of an educative feature that was not coded was the identification of sources of funding to develop innovative programs (What on Earth?, p. 14). This information could potentially be very useful to enterprising and creative teachers, but did not fit within the design heuristics.

5. Potential for Additional Educative Features.

In general, as noted, the *Insights* materials were extremely educative. It might be helpful, however, to signal how educative the materials are for teachers by mentioning this characteristic explicitly in the Implementation Guide.

VIII. Prentice Hall: Biology

The *Prentice Hall—Biology* textbook is designed for ninth and tenth grade high school students. The teacher’s materials are formatted as a wraparound edition of the student textbook. It includes several textboxes in the margins that provide teachers with subject matter knowledge, reading strategies, student misconceptions, ideas for how to support diverse learners, and technology links.

1. Description of Most Common Codes

This set of curriculum materials included three predominant supports for teachers. The most common educative feature was 9B, or subject-matter support for teachers; 38 instances were coded for this feature in the pages from the ecology and evolution sections. The next most commonly coded points were 3B, supports for helping teachers identify students’ likely ideas (11 instances coded), and 3C, supports for helping teachers deal with students’ misconceptions (11 instances coded). Finally, there were four additional codes that were found less frequently through the coded pages.

Point 3B: Supports Teachers in Identifying Students' Ideas About Science

- **DESCRIPTION:** A common example of this educative feature was when the materials provided the teacher with an example of a likely misconception that students might have with regard to a particular topic. This common example provided strong evidence for this code.
- **COMMON EXAMPLE:** “Students may hold the misconception that because evolution is called a theory, it is no more likely to be true than any other explanation for biological diversity.” (p. 369).
- **LOCATION:** Examples of this educative feature were found in the “Address Misconceptions” textboxes in the teachers’ materials.

Point 3C: Supports Teachers in Dealing with Students' Ideas About Science

- **DESCRIPTION:** A common example of this educative feature was when the materials told the teacher to tell students the ‘right answer’ in order to address this misconception. This type of example provided weak evidence in support of this code. However, there were a few instances that suggested that the teachers do a particular demonstration and ask certain questions to help students address their misconception.
- **COMMON EXAMPLE:** In response to the 3B code above, the teacher is told to stress that evolution is a theory that is supported by evidence. (p. 369).
- **LOCATION:** Examples of this educative feature were found in the “Address Misconceptions” textboxes in the teachers’ materials.

Point 9B: Supports Teachers in the Development of Subject Matter Knowledge

- **DESCRIPTION:** This point was the most commonly coded educative feature in these materials. The subject-matter supports were all short summaries of additional subject matter about a particular topic that students were reading about in the textbook. This information was frequently presented at a level beyond the level of understanding required by students.

- **COMMON EXAMPLE:** In one “Facts and Figures” textbox, the teacher is provided with information on biotic potential and how it relates to the figures in the text as well as how it relates to later topics. (p. 118)
- **LOCATION:** The materials provided subject-matter supports for teachers in the form of textboxes in the outer margins of the teachers’ materials. These textboxes were typically labeled as “Make Connections,” “History of Science,” and “Facts and Figures.” In addition, the introductory pages for the unit typically provided teachers with subject matter knowledge about the entire unit.

2. Description of Educative Features in Lab Manual

The materials included an annotated teacher lab manual. The lab manual annotations included information on how to prepare solutions, care for living organisms, safety information, and suggestions for when to demonstrate certain procedures for students, as well as answers to student lab questions. Some sections of the teacher’s lab manual pointed out potential pitfalls and occasionally helped the teacher think about implementation of activities; these appeared to be the only educative features as defined by the heuristics.

3. Description of Educative Features in Introductory Materials

The text included several different kinds of information in the introduction to the textbook. Such information included an explanation about the layout of the features in the text, charts for how different chapters aligned with both the National Science Education Standards and Benchmarks for Science Literacy, and information about the research that was conducted during the development of the textbook. The introductory materials also included a section entitled “Foundational Research: Inquiry in the Science Classroom.” This one-page section included a definition of inquiry and a description of features associated with an inquiry-based science classroom. In addition, there were sections on reading comprehension, differentiated instruction, assessment and “Instructional Technology.” Each of these sections very briefly defined each topic and provided information on how the topics linked to particular features in the teacher’s edition of the textbook and other ancillary materials. Thus, the introductory materials were quite brief (32 pages total) and not rich in educative features.

4. Other Educative Features Not Coded

Even though we did not code for this, the text included suggestions for how the teacher could help his or her students deal with mathematical skill issues. For example, the Make Connections: Mathematics section on p. 401 points out the quadratic nature of genotype proportions in relation to allele frequencies.

5. Potential for Additional Educative Features

This textbook was very strong in providing teachers with subject matter knowledge. It also highlighted several student misconceptions. However, there were many other instances that had the potential to be educative for teachers. For example, the materials rarely provided teachers with a rationale for why a particular technique/procedure was important and support for how

teachers might use it in their classroom. Additionally, there was a lot of potential to expand upon the “Address Misconceptions” textboxes. The text typically pointed out students’ misconceptions and gave the teacher a statement for handling the students’ misconceptions. These sections could better support teachers in dealing with students’ misconceptions by providing questions, demonstrations, and/or phenomena for the teacher to use to help his or her students address their misconceptions. Finally, the introductory materials indicated that the labs in the textbook incorporated both “cookbook” labs and labs in which students design procedures. Although an examination of the teacher annotated lab manual was not complete, there seemed to be a lot of opportunities to design more inquiry-oriented labs and supports for teachers within those labs.

Final Rankings

As both the quantitative and narrative analyses show, we found that two sets of curriculum materials were much more educative than the rest. These materials included the Kendall Hunt: BSCS: *Biology—A Human Approach*, and EDC: *Insights*. It would be difficult to defend the position that either of these was superior to the other, but there was ample evidence that both were superior to the rest of the texts examined.

Biology—A Human Approach. The narrative for *A Human Approach* shows that this curriculum material provided strong evidence for point 3B, supporting teachers in identifying students' ideas about science. Furthermore, the materials tended to help the teacher deal with students' ideas (point 3C) in a way that subtly encouraged the teachers to guide students to build their own understanding of science. *A Human Approach* provided rationales for specific questions (point 4C) and included scaffolding for the teacher to lead a debate about scientific issues. It also provided rationales and implementation guidance for how to use specific questions and activities to foster productive communication in class (points 8A and 8B). Along with the introductory materials, which focused on cooperative learning in the classroom, these materials supported the teacher extensively in learning to transform the classroom into a community of learners. Overall, these common educative features tended to provide useful, in-depth support for the teacher.

The quantitative analyses show that *A Human Approach* is the second highest ranked set of materials for total number of educative features coded, despite having the least amount of support for SMK of any material. Additionally, *A Human Approach* ranked highest in supports for PCK for inquiry because of its focus on questions and communication. Its high level of support for PCK for inquiry and second highest support for PCK for topics led to its top ranking in supports for PCK. As described above, many of these educative features that were coded were of high quality. Furthermore, supports for teachers were provided in a variety of categories, greater than any other set of curriculum materials, suggesting that these materials were rich with regard to the different types of support it provided for the teacher.

Despite these strengths, the materials still have room for improvement. For example, the educative supports for the teacher tended to be thoroughly integrated into the non-educative text in the materials. The integrated nature of the teacher materials may lead teachers not to be aware that the materials have been designed to support their learning and may make it difficult for teachers to easily locate a given type of support. Therefore, the materials may better support teachers' learning by making the educative support more explicit to teachers. Additionally, these curriculum materials can benefit from increased support for teachers' SMK (heuristic 9) as well as increased opportunities for students to engage in scientific investigations and support for teachers to help them engage their students in this experimental work (i.e., heuristics 5 and 6: engaging students in collecting and analyzing data and in designing investigations, respectively). These materials can also better support teachers by increasing scaffolding for teachers in engaging students in making explanations based on evidence (heuristic 7). It must be noted, however, that these weaknesses were common to all materials.

Insights. The narrative for *Insights* stressed the very strong educative nature of the teacher handbook, noting that many features were high level, substantive, in depth, and useful. The materials provided strong support for teachers in identifying and dealing with students' ideas (point 3B and 3C). They also frequently provided well-designed scaffolding for teachers' subject matter knowledge (point 9B). The introductory materials were exceptionally strong, including

sophisticated guidance into the philosophy and design of the course. This type of explicit attention to meta-level concerns seems likely to engender what Brown and Edelson (2003) term teachers' pedagogical design capacity.

The quantitative analyses also revealed the strength of these materials. The text ranked highest for total number of instances of educative features and provided support in all three categories. More specifically, it ranked second in PCK for inquiry, third in support for SMK, and first in PCK for topics. It also ranked second overall in total number of different types of points coded for, suggesting that the materials provided a rich variety of types of educative supports for teachers. Additionally, the location of the educative features was fairly predictable, making it easy for teachers to find a given type of support. Finally, despite the strength of these materials, the educative supports within *Insights* can be enhanced by providing more support for teachers' PCK for scientific inquiry—specifically with helping teachers engage their students in asking and answering scientifically oriented questions, designing investigations, gathering and analyzing evidence, developing explanations, and communicating with others.

While much less educative than the two texts mentioned above, Glencoe: *Biology—A Community Context* and Glencoe: *Biology—An Everyday Experience* might appear to be somewhat more educative than the rest of the materials. However, we hesitate to consider these two materials as part of an intermediate tier, as the narratives reveal that the quality of the features tends to be low. Thus, we feel that the evidence warrants ranking *Insights Human* and *Approach* as the most educative texts, with no distinction among the remaining materials.

Conclusions

Role of Educative Curriculum Materials in a Learning Environment for Teachers

To learn science through inquiry, students need a supportive learning context to help them learn new ways of knowing, doing, and talking science. In an analogous manner, teachers need a supportive learning environment to not only learn about science but also to learn how to teach science. More specifically, teachers need opportunities to learn about and adopt reform-oriented practices, which promote teaching science through inquiry. Educative curriculum materials play a pivotal role in a learning environment for teachers in order to help teachers use more reform-oriented teaching strategies (Ball & Cohen, 1996; Schneider & Krajcik, 2002). Embedding learning opportunities within curriculum materials is a particularly fruitful idea because such materials are intimately connected to teachers' planning and enactment and thus can situate teacher's learning in their own practice (Brown, Collins, & Duguid, 1989; Putnam & Borko, 2000). Additionally, because most teachers use curriculum materials in their daily work, curriculum materials can provide ongoing support (Collopy, 2003) and sustain reform initiatives on a large scale (Schneider & Krajcik, 2002). Therefore, by designing curriculum materials with the role of the teacher in mind, they may be used as effective tools in promoting change in science classrooms.

As part of a learning environment for teachers, educative curriculum materials can play a fundamental role in shaping what teachers think and do in many ways. At a basic level, curriculum materials provide "ideas and skills to be taught, make connections between related ideas, provide contexts for the presentation of ideas, and sequence activities" (Center for Curriculum Materials in Science, n.d.). In addition to these basic features, curriculum materials that are designed to be educative for teachers can include rationales and implementation guidance to help teachers think about and use these activities and ideas in productive ways (Davis & Krajcik, 2005). They also provide opportunities for teachers to increase their pedagogical design capacity by enabling teachers to serve as agents in the design of the materials and to make curricular adaptations that achieve productive instructional ends (Brown & Edelson, 2003).

These educative curricular features provide opportunities to promote teachers' learning about science and how to teach science by encouraging teachers to interpret these activities, ideas, and underlying assumptions with regard to their current knowledge and beliefs. They also provide teachers with support in making decisions about how the materials should be used during planning and during instruction when teachers respond to students' encounters with the instructional activities (Remillard, 2000). Additionally, educative materials that are consistent with reform documents can help teachers learn about new ways of teaching science that are more aligned with the goals of science education. They can also provide teachers with the opportunity to practice new ideas in their classroom practice and reflect upon these experiences, thereby assisting them in actively constructing their knowledge of reform-oriented practices and modifying their beliefs about teaching and learning (Borko & Putnam, 1996). In these ways, curriculum materials that are designed with explicit pedagogical support can provide support for teachers' learning and practice and thus ultimately support for reform efforts.

Finally, in using educative curriculum materials to promote teachers' learning, researchers have found that multiple sources of professional development are more effective than using just one source in a learning environment for teachers (Fishman, Marx, Best, & Tal, 2003).

Consequently, “used alone, educative curriculum materials serve as only one perturbation to the status quo” (Davis & Krajcik, 2005, p.6). Thus, promoting teachers’ learning through curriculum materials might best be supported if the materials are embedded within a professional development program aimed at helping teachers become more effective science instructors (Ball & Cohen, 1996; Davis & Krajcik, 2005). Complementing educative curriculum materials with additional forms of support such as face-to-face summer workshops, online discussion boards, and ongoing professional development during the school year (Putnam & Borko, 2000; Schneider & Krajcik, 2002) may better facilitate teacher change.

Implications for the Design of Educative Curriculum Materials

The results of this study of high school biology curriculum materials have implications for the future design of curriculum materials for teachers of biology and other subjects as well. First, we found in this study that most of the curriculum materials provided little or no support for inquiry. This finding is unsurprising since most of the textbooks included few inquiry-oriented activities for students, and consequently, few opportunities (or need) to support the teacher’s understanding of inquiry-oriented science. Therefore, this finding suggests that the overall design of textbooks needs to be more inquiry-oriented, that is, they need to provide more opportunities for students to ask scientifically oriented questions, design investigations to answer those questions, collect and analyze data, develop evidence-based explanations, and communicate those findings with others (Krajcik et al., 2000). In addition to including more inquiry-oriented activities for students, more supports for teachers are also needed. Teachers need support in understanding the importance of inquiry in general and of each of these inquiry practices, as well as how to effectively use and modify each of these practices in their own classroom instruction.

Another pivotal finding from this study was that the number of instances coded for particular educative features was not necessarily an indicator of how educative the curriculum materials were for teachers. In other words, we found that the helpfulness and richness of the support were characteristics of the educative feature that were just as important as the frequency of the supports in the materials. For example, the textbooks in this study typically included numerous subject matter supports for teachers by presenting teachers with additional information about a science topic. Additionally, the textbooks tended to provide frequent support for learning about students by giving teachers information about students’ likely ideas about particular science topics and ideas for how to deal with students’ misconceptions. However, even though examples of these types of support appeared frequently in the materials, they sometimes provided poor examples for these types of support. For example, the subject matter knowledge geared toward the teacher was sometimes not relevant to the lesson. Additionally, several of the suggestions in the textbooks for how to deal with students’ misconceptions suggested that the teacher simply tell his or her students the correct scientific answer—an approach not likely to actually promote student learning. Moreover, most of the educative features, in general, tended to provide extremely limited support (e.g., a single sentence) rather than providing rich descriptions and detailed information for teachers. Therefore, these findings suggest that curriculum materials need to include not only frequent, consistent support for teachers but also strong examples of support that are pedagogical useful and sufficiently in depth.

A third implication from this study is the need to design educative curriculum materials with more supports for PCK for topics. Even though support for PCK for topics was the most

prevalent kind of support in the materials, most of these supports pertained to heuristic 3, that is, helping the teacher anticipate and deal with students' ideas about science. Therefore, more supports for helping teachers engage students with topic-specific scientific phenomena (heuristic 1) and helping teachers use instructional representations (heuristic 2) are needed in the future design of curriculum materials. For example, in addition to providing teachers with physical and vicarious experiences to make phenomena accessible to students, curriculum materials also need to provide teachers with rationales for these experiences and guidance on how to use and/or adapt these experiences so they can use them effectively in their classroom. Similarly, in addition to providing teachers with appropriate instructional representations of scientific phenomena to use with their students, curriculum materials also need to provide teachers with rationales and implementation guidance for these representations.

Finally, the findings from this study suggest that curriculum materials overall need to provide more rationales for teachers. Rationales are needed to make explicit the intentions of the curriculum developers, thereby helping teachers understand the developers' pedagogical judgments and curricular decisions (Ball & Cohen, 1996; Davis & Krajcik, 2005; Remillard, 2000). Rationales are also needed to explain why particular instructional approaches and content are appropriate for instruction, enabling teachers to reflect on the assumptions underlying particular ideas and activities and thus make informed decisions about enactment. Therefore, by designing curriculum materials with more rationales, teachers will have more opportunities to increase their leaning about how to make productive adaptations that are consistent with reform-oriented goals.

Implications for Refinement of Design Heuristics for Educative Curriculum Materials

This study provides ideas about how to enhance the design heuristics for educative curriculum materials developed by Davis and Krajcik (2005) to be more complete and consistent for use in the design and/or evaluation of future curriculum materials. To create consistency across all of the PCK design heuristics, each heuristic needs to be redesigned to include the same four components. First, teachers need to be provided with well-designed instructional approaches, activities, and tasks. Second, the materials need to provide teachers with rationales to uncover the curriculum developers' underlying assumptions and pedagogical decisions with regard to these tasks. Teachers may need *specific* rationales for why particular instructional approaches are scientifically and pedagogically appropriate as well as *general* rationales for why it is important for students to engage in these tasks more generally. For example, curriculum materials could provide teachers with specific rationales for why particular questions in the lesson are appropriate and general rationales for why it is important for students to ask and answer scientifically oriented questions. Third, teachers need to be given implementation guidance to help them effectively use the instructional approaches suggested in the materials. Teachers may need specific and general guidance on how to use the instructional approaches in productive ways with their students. Finally, curriculum materials need to provide teachers with adaptation guidance to help them make informed decisions about how to adapt the instructional approaches, activities, and tasks to address the unique demands of their instructional context.

Finally, this study surfaced the need for the creation of additional design heuristics to be included with the original nine heuristics developed by Davis and Krajcik (2005). These additions are not surprising since the developers explicitly clarified that their original list of design heuristics was non-exhaustive and was developed by design. Currently, the design

heuristics suggest that supports need to be provided for SMK and for some aspects of PCK. To provide further support for PCK, and in particular, support for PCK for scientific inquiry, the following design heuristics need to be added. Ideas for additional design heuristics emerged from this study and are supported by suggestions within the research literature.

- **PCK of science curricula:** Design heuristics need to be developed to help teachers develop knowledge about age-appropriate learning goals and objectives in science. Teachers need support in seeing how key learning goals and concepts are connected across time and why these learning goals and content are important to teach (Ball & Cohen, 1996; Remillard, 2000; Schneider & Krajcik, 2002). They also need to help teachers understand the sequencing of particular activities and tasks and why these activities are selected. Magnusson and colleagues (1999) highlight this type of knowledge as an important aspect of PCK that teachers need to know to be effective science teachers. Shulman (1986) also recognized that curricular knowledge was an important aspect of teacher knowledge.
- **PCK of assessment of scientific literacy:** Design heuristics need to be developed to help teachers understand the different kinds of student learning that need to be assessed and the different methods for assessing students' learning. Magnusson and colleagues (1999) highlight this type of knowledge as an important aspect of PCK that teachers need to know to be effective science teachers.
- **PCK of orientations toward teaching the subject matter:** Design heuristics need to be developed to help teachers develop beliefs that are compatible with reform-oriented goals (Ball & Cohen, 1996; Collopy, 2003). Magnusson and colleagues (1999) highlight this type of knowledge as an important aspect of PCK that teachers need to know to be effective science teachers.
- **PCK of learners:** The current design heuristics suggest that curriculum materials need to help teachers develop their knowledge of their students by learning how to anticipate and deal with students' likely ideas about science. This type of knowledge is an important aspect of PCK (Shulman, 1986) and important for helping teachers become effective science teachers (Magnusson et al., 1999). However, this design heuristic needs to provide additional support for teachers' PCK of students' understanding of science. For example, teachers need support with understanding the different kinds of prerequisite knowledge that students need to have for learning a particular topic (Schneider & Krajcik, 2002). Teachers also need to know the appropriate level of understanding that students need to achieve for particular topics (Schneider & Krajcik, 2002). Finally, supports need to be developed for helping teachers address the unique characteristics of their learners by helping them make science relevant, interesting, and understandable to different populations of students.
- **PCK for scientific inquiry:** The current design heuristics suggest that support be developed for one aspect of this type of specialized knowledge, that is, knowledge of instructional strategies to support students' inquiry practices. Consequently, the design heuristics need to provide further support for teachers' PCK for scientific inquiry. Zembal-Saul and Dana (2000) identified four additional components of this knowledge type by building on Magnusson and colleagues' framework for PCK for science teaching. In addition to supports for instructional strategies associated with inquiry, this work highlights the need to provide support for developing teachers' knowledge of the

orientations toward scientific inquiry, students' understandings of inquiry, appropriate curricula for inquiry, and formative and summative assessment techniques for inquiry.

In these ways, the design heuristics can be refined to be more inclusive and consistent for use in designing and evaluating curriculum materials for particular educative supports for teachers. This refinement of the design heuristics takes us "one step closer to the principled design of educative curriculum materials" (Davis & Krajcik, 2005, p.4).

References

- American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. New York: Oxford University Press.
- Ball, D. L., & Cohen, D. K. (1996). Reform by the book: What is—or might be—the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, 25(9), 6-8, 14.
- Borko, H., & Putnam, R. T. (1996). Learning to teach. In D. C. Berliner (Ed.), *Handbook of educational psychology*. New York, NY: Macmillan.
- Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18, 32-42.
- Brown, M., & Edelson, D. (2003). *Teaching as design: Can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice?* (Design Brief). Evanston, IL: Center for Learning Technologies in Urban Schools.
- Bruer, J. T. (n.d.) The mind's journey from novice to expert. *James S. McDonnell Foundation Staff Publications*. Retrieved Dec. 2, 2005 from www.jsmf.org/about/j/minds_journey.htm.
- Burton, J.K., Moore, D.M., & Magliaro, S.G. (1996). Behaviorism and instructional technology. In D.H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 46-67). New York, NY: Simon and Schuster.
- Center for Curriculum Materials in Science. (n.d.) CCMS Core Principles: Focusing materials on learning goals. Retrieved January 23, 2006 from http://www.sciencematerialscenter.org/about_core_goals.htm.
- Collopy, R. (2003). Curriculum materials as a professional development tool: How a mathematics textbook affected two teachers' learning. *The Elementary School Journal*, 103(3), 227–311.
- Crawford, B. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching*, 37(9), 916-937.
- Davis, E. A., & Krajcik, J. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher*, 34(3), 3-14.
- Edelson, D. C. (2001). Learning-for-use: A framework for integrating content and process learning in the design of inquiry activities. *Journal of Research in Science Teaching* (38):355-385.
- Fishman, B., Marx, R., Best, S., & Tal, R. (2003). Linking teacher and student learning to improve professional development in systemic reform. *Teaching and Teacher Education*, 19(6), 643-658.
- Heaton, R. M. (2000). *Teaching mathematics to the new standards: Relearning the dance*. New York: Teachers College Press
- Kesidou, S., & Roseman, J. E. (2002). How well do middle school science programs measure up? Findings from Project 2061's curriculum review. *Journal of Research in Science Teaching*, 39(6), 522-549.

- Krajcik, J., Blumenfeld, P., Marx, R., & Soloway, E. (2000). Instructional, curricular, and technological supports for inquiry in science classrooms. In J. Minstrell & E. Van Zee (Eds.), *Inquiring into inquiry learning and teaching in science* (pp. 283-315). Washington, DC: American Association for the Advancement of Science.
- Krajcik, J.S. & Blumenfeld, P. (2006). Project-based learning. To appear in Sawyer, R. K. (Ed.), *The Cambridge handbook of the learning sciences*. New York: Cambridge.
- Linn, M. C., Davis, E. A., & Eylon, B.-S. (2004). The scaffolded knowledge integration framework for instruction. In M. C. Linn, E. A. Davis & P. Bell (Eds.), *Internet Environments for Science Education* (pp. 47-72). Mahwah, NJ: Lawrence Erlbaum Associates.
- Lortie, D. (1975). *Schoolteacher: A sociological study*. Chicago: University of Chicago Press.
- Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K. (1998). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.
- Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95-132). The Netherlands: Kluwer Academic Publishers.
- Marx, R. W., Blumenfeld, P. C., Krajcik, J. S. & Soloway, E. (1997). Enacting project-based science. *The Elementary School Journal*, 97(4), 341-358.
- Miller, G. A. (2003). The cognitive revolution: A historical perspective. *Trends in Cognitive Science* (7)3, 141-144.
- National Research Council (1996). *National Science Education Standards*. Washington, D.C. National Academy Press. [Viewed electronically]
- National Research Council (2000). *How people learn: Brain, mind, experience, and school*. (Expanded Edition). Bransford, J. D., A. L. Brown, and R. R. Cocking, (Eds.). Washington, D.C.: National Academy Press.
- National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, D.C.: National Academy Press.
- Northwestern University (2006). Learning sciences overview. *School of Education and Social Policy*. Retrieved April 15, 2006, from <http://www.sesp.northwestern.edu/ls/info/overview/>.
- Project 2061 (n.d.). *Project 2061 instruction criteria*. Retrieved Feb. 4, 2006, from www.project2061.org/events/meetings/textbook/literacy/cdrom/CRITERIA/CRITERIA.htm.
- Putnam, R., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, 29(1), 4-15.
- Remillard, J. T. (2000). Can curriculum materials support teachers' learning? Two fourth-grade teachers' use of a new mathematics text. *The Elementary School Journal*, 100(4), 331-350.
- Schneider, R., & Krajcik, J. (2002). Supporting science teacher learning: The role of educative curriculum materials. *Journal of Science Teacher Education*, 13(3), 221-245.

Schneider, R., Krajcik, J. & Blumenfeld, P. (2005). Enacting reform-based science materials: The range of teacher enactments in reform classrooms. *Journal of Research in Science Teaching*, 42(3), 283-312.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(5), 4-14.

Tyack, D., & Cuban, L. (1995). *Tinkering toward utopia: A century of public school reform*. Cambridge, MA: Harvard University Press.

Zemal-Saul, C. & Dana, T. M. (2000). Exploring the nature, sources, and development of pedagogical content knowledge for supporting children's scientific inquiry (PCK-SI). A paper presented at the annual meeting of the National Association for Research in Science Teaching, New Orleans, LA.

Appendix A: Operationalized Design Heuristics Used for Analysis of Curriculum Materials

Design Heuristic 1 - Supporting Teachers in Engaging Students with Topic-Specific Scientific Phenomena	Category
1A. Curriculum materials should provide teachers with productive physical (and vicarious) experiences that make phenomena accessible to students	Non-Educative Feature
1B. [Curriculum materials should provide] rationales for why these experiences are scientifically and pedagogically appropriate	Rationale
1C. Curriculum materials should help teachers adapt and use these experiences with their students, for example by making recommendations about which experiments are important and feasible for students to conduct themselves and which might be more successful as demonstrations.	Implementation Guidance
1D. Curriculum materials should warn of potential pitfalls with specific physical experiences.	Implementation Guidance
1E. Curriculum materials should suggest and help teachers think about productive sequences for experiences.	Implementation Guidance
Design Heuristic 2 - Supporting Teachers in Using Scientific Instructional Representations	Category
2A. Curriculum materials should provide appropriate instructional representations of scientific phenomena (e.g., analogies, models, diagrams)	Non-Educative Feature
2B. [Curriculum materials should] support teachers in adapting and using those representations, for example by noting changes that would lead to inaccuracies with regard to the science content. (For example, the curriculum materials could help teachers determine the most salient features of an instructional representation.)	Implementation Guidance
2C. Curriculum materials should be explicit about why a particular instructional representation is scientifically and pedagogically appropriate. (For example, the materials might show what non-scientific ideas it might promote if used improperly.)	Rationale
Design Heuristic 3 - Supporting Teachers in Anticipating, Understanding, and Dealing with Students' Ideas About Science	Category
3A. Curriculum materials should help teachers recognize the importance of students' ideas.	Rationale
3B. [Curriculum materials should] help teachers identify likely student ideas within a topic.	Implementation Guidance
3C. Curriculum materials should help teachers gain insight into how they might be able to deal with the ideas in their teaching, for example by giving suggestions of thought experiments likely to promote the development of more scientific ideas.	Implementation Guidance

Design Heuristic 4 - Supporting Teachers in Engaging Students in Questions	Category
4A. Curriculum materials should provide driving questions for teachers to use to frame a unit.	Non-Educative Feature
4B. [Curriculum materials] should help teachers identify questions that they can use with their students, including focus questions for guiding a class discussion.	Non-Educative Feature
4C. Curriculum materials should help teachers understand why these are scientifically and pedagogically productive questions.	Rationale
4D. Curriculum materials should help teachers adapt and use the questions. For example, they should help the teacher make the questions more relevant to their students.	Implementation Guidance
4E. Curriculum materials should help teachers engage their students in asking and answering their own scientific questions, by providing suggestions of productive questions and ideas about how to guide students toward those or other productive questions.	Implementation Guidance

Design Heuristic 5 - Supporting Teachers in Engaging Students With Collecting and Analyzing Data	Category
5A. Curriculum materials should provide teachers with approaches to help students collect, compile, and understand data and observations.	Non-Educative Feature
5B. Curriculum materials should help teachers understand why these opportunities are scientifically and pedagogically appropriate.	Rationale
5C. Curriculum materials provide teachers with ideas about how to use these opportunities effectively in their practice.	Implementation Guidance
5D. Curriculum materials should help teachers understand why the use of evidence is so important in scientific inquiry.	Rationale
5E. Curriculum materials should help teachers adapt and use these approaches across multiple topic areas even when the data being collected seem fairly different (e.g. plant growth as opposed to weather conditions).	Implementation Guidance

Design Heuristic 6 - Supporting Teachers in Engaging Students in Designing Investigations	Category
6A. Curriculum materials should help teachers recognize the importance of sometimes having students design their own investigations.	Rationale
6B. Curriculum materials should provide guidance for how teachers can support students in doing so, by providing ideas for appropriate designs and suggestions for improving students' inappropriate designs.	Implementation Guidance

Design Heuristic 7 - Supporting Teachers in Engaging Students in Making Explanations Based on Evidence		Category
7A.	Curriculum materials should provide clear recommendations for how teachers can support students in making sense of data and generating explanations based on evidence that the students have collected and justified by scientific principles that they have learned.	Implementation Guidance
7B.	The supports should include rationales for why engaging students in explanation is important in scientific inquiry.	Rationale
7C.	The supports should include rationales for why these particular approaches for doing so are scientifically and pedagogically appropriate.	Rationale

Design Heuristic 8 - Supporting Teachers in Promoting Scientific Communication		Category
8A.	Curriculum materials should provide suggestions for how teachers can promote productive communication among students and teachers in conversations and student artifacts.	Implementation Guidance
8B.	Curriculum materials should provide rationales for why particular approaches for promoting communication (e.g., class discussions, student presentations, lab reports) are scientifically and pedagogically appropriate.	Rationale

Design Heuristic 9 - Supporting Teachers in the Development of Subject Matter Knowledge		Category
9A.	<i>Curriculum materials should support teachers in developing factual and conceptual knowledge of science content.</i>	<i>Non-Educative Feature</i>
9B.	Support should be presented at a level beyond the level of understanding required by the students, to better prepare teachers to explain science concepts and understand their students' ways of understanding the material. For example, the curriculum materials could help teachers see how the scientific ideas relate to real-world phenomena, activities in the unit, and common student misconceptions.	Educative Feature
9C.	Curriculum materials should help teachers understand] why strong subject matter knowledge is important for teaching.	Rationale

Appendix B: Explanation of Inter-rater Reliability for *Insights*

It is important to note that the coding of the *Insights* materials did not reach our goal of 80% inter-rater reliability during the time we had available to code the materials. Our highest reliability was 79%.

Because our first practice coding session was conducted using the *Insights* genetics materials, all the coders were familiar with *Insights*. It was the consensus of all of the coders that the *Insights* materials were rich in their provision of educative elements for teachers. It also became apparent that *Insights*'s educative features usually integrated various heuristics. Whereas other texts we reviewed might have had only one code (i.e., one instance of an educative element) every several pages, *Insights* often had multiple codes per page and even multiple codes per paragraph.

An example from page 54 of *What On Earth?* might help to illustrate the complexity in coding the *Insights* materials. Under the heading "Technology Tools", the materials put forward a rationale for using this simulation ("It complements this module by extending student experiences and allowing them to manipulate variables"; point 2C). The text follows this statement with a list of concepts explored in the simulation, which might be considered as further rationale for using the simulation. The text later provides implementation guidance for the representation (point 2B), stating, "If used following the 'Lynx and Hare' activity, it will help students develop a deeper understanding of the variables...students will need to...be prepared to spend some time thinking and talking about what they are seeing and learning". The next paragraph puts forward ambiguous (and eventually not coded) examples of supports for identifying and dealing with students' likely ideas; the nature of the student difficulty ("the complexity and flexibility of this simulation") was quite different from most of the examples of student ideas that we saw in other texts. Most texts only helped teachers identify likely misconceptions, and not more complex examples of student difficulties like this one. All of these statements were embedded within rich and lengthy text focused on various aspects of using the simulation.

This brief example shows how a single half-page of text might have numerous instances of educative elements embedded, and that several of those instances might be ambiguous in terms of how to code them. The coders needed to identify exactly the same elements as educative, and then also categorize them in the same way, in order for the code to count as a match. With so many educative elements embedded throughout the text and with each so well integrated, it proved difficult to achieve reliability with this text. With that said, the coders agreed with high reliability about whether segments of the text were educative for teachers or not, and as stated above, the coders also agreed that the *Insights* materials stood above many of the other materials we reviewed in terms of how educative they were for teachers, in general.

Appendix C: Raw and Adjusted Data for Number of Educative Instances in the Eight Sets of Curriculum Materials

1. Glencoe: A Community Context

1-GCC	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C
Section1	3	1	0	2	0	0	1	3	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0
Section2	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Section3	1	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Section4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Section5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
ECO TOTAL	8	6	1	2	0	0	1	6	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	16	0
Section1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Section2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0
Section3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Section4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0
EVO TOTAL	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	12	0
TOTAL	9	7	2	2	1	0	1	7	1	1	0	2	0	0	0	0	0	0	0	0	0	2	0	28	0

Only 42 pages were coded in the evolution section. Therefore, the number of instances recorded in the evolution section was multiplied by a ratio of $X*50/42$ to extrapolate what the numbers might have been if 50 pages had been coded.

ECO TOTAL	8	6	1	2	0	0	1	6	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	16	0
EVO TOTAL ADJUSTED	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	14	0
TOTAL ADJUSTED	9	7	2	2	1	0	1	7	1	1	0	2	0	0	0	0	0	0	0	0	0	2	0	30	0

2. Glencoe: Everyday Experience

2-GEE	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C
Section1	1	0	1	0	3	2	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Section2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Section3	3	1	1	0	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Section4	3	0	2	0	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
ECO TOTAL	7	1	4	0	9	2	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
Section1	1	0	0	0	2	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Section 2	0	0	2	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
EVO TOTAL	1	0	2	0	2	2	0	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
TOTAL	8	1	6	0	11	4	0	8	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0

The 4 sections coded in the ecology section totaled approximately 50 pages. However, only 30 pages were coded in the evolution section. Therefore, the number of instances recorded in the evolution section was multiplied by a ratio of $X*50/30$ to extrapolate what the numbers might have been if 50 pages had been coded.

ECO TOTAL	7	1	4	0	9	2	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
EVO TOTAL ADJUSTED	2	0	3	0	3	3	0	5	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
TOTAL ADJUSTED	9	1	7	0	12	5	0	10	10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0

3. Glencoe: Dynamics of Life

3-GDL	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C
Section1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
Section2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Section3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Section4	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Section5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ECO TOTAL	0	0	1	0	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	1
Section1	0	1	0	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Section2	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Section3	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Section4	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Section5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
EVO TOTAL	0	3	0	0	4	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
TOTAL	0	3	1	0	6	3	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	1

4. Glencoe: Living Systems

4-GLS	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C
Section1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Section2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Section3	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Section4	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Section5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
ECO TOTAL	1	0	1	0	1	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Section1	0	0	1	0	2	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	3	0
Section2	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Section3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Section4	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Section5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EVO TOTAL	0	0	1	0	2	1	0	5	4	0	1	0	0	0	0	0	0	1	0	0	0	1	0	11	0
TOTAL	1	0	2	0	3	1	0	7	6	0	1	0	0	0	0	0	0	1	0	0	0	1	0	16	0

5. Kendall Hunt: BSCS: A Human Approach

5-KHA	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C
Section1	0	0	1	0	0	0	2	4	2	5	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Section2	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Section3	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Section4	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	2	0	0	1	0	0	0
Section5	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
ECO TOTAL	0	0	2	0	1	0	4	10	2	5	0	1	1	2	0	0	0	1	2	0	0	3	2	2	0
Section1	0	1	1	0	4	1	0	6	3	3	0	0	0	0	2	0	0	0	0	0	0	2	0	2	0
Section2	1	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	3	7	0	0
Section3	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Section4	1	0	0	0	0	0	0	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Section5	1	0	0	0	0	2	0	4	4	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0
EVO TOTAL	3	1	1	0	4	3	0	18	11	6	0	0	0	0	2	0	0	0	1	0	0	6	8	5	0
TOTAL	3	1	3	0	5	3	4	28	13	11	0	1	1	2	2	0	0	1	3	0	0	9	10	7	0

6. Kendall Hunt: BSCS: An Ecological Approach

6-KEA	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C	
Section1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	
Section2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	
Section3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
Section4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	
Section5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	
Section6	3	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
ECO TOTAL	7	0	0	0	0	0	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	
Section1	2	1	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	
Section2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	
Section3	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
Section4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	
Section5	1	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
EVO TOTAL	3	2	2	0	0	1	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	
TOTAL	10	2	2	0	0	1	0	7	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	

The 6 sections coded in the ecology section totaled approximately 50 pages.

7. EDC: Insights

7-EDCI	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C
Section1	0	3	2	0	1	0	0	2	1	2	0	0	0	0	0	0	2	2	0	0	0	0	2	3	0
Section2	4	2	1	1	3	3	0	2	1	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Section3	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Section4	0	0	0	0	1	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0
Section5	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
ECO TOTAL	4	8	4	1	7	5	0	6	3	4	0	0	1	1	0	0	2	2	0	0	0	3	3	6	0
Section1	0	0	0	0	4	3	0	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0
Section2	0	0	0	0	2	1	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
EVO TOTAL	0	0	0	0	6	4	0	11	5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	0
TOTAL	4	8	4	1	13	9	0	17	8	4	0	0	1	1	0	0	2	2	0	0	0	3	5	20	0

The 2 sections coded in the evolution section totaled 32 pages. Therefore, the number of instances recorded in the evolution section was multiplied by a ratio of $X*50/32$ to extrapolate what the numbers might have been if 50 pages had been coded.

7-EDCI	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C
ECO TOTAL	4	8	4	1	7	5	0	6	3	4	0	0	1	1	0	0	2	2	0	0	0	3	3	6	0
EVO TOTAL ADJUSTED	0	0	0	0	9	6	0	17	8	0	0	0	0	0	0	0	0	0	0	0	0	0	3	22	0
TOTAL ADJUSTED	4	8	4	1	16	11	0	23	11	4	0	0	1	1	0	0	2	2	0	0	0	3	6	28	0

8. Prentice Hall: Biology

8-PHB	1B	1C	1D	1E	2B	2C	3A	3B	3C	4C	4D	4E	5B	5C	5D	5E	6A	6B	7A	7B	7C	8A	8B	9B	9C
Section1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Section2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Section3	0	0	1	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
Section4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Section5	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
ECO TOTAL	0	1	2	0	2	1	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0
Section1	0	0	0	0	1	1	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
Section2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Section3	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
EVO TOTAL	0	0	0	0	1	1	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
TOTAL	0	1	2	0	3	2	0	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	0

The 3 sections coded in the evolution section totaled approximately 50 pages