Publication date: April 13, 2010

Questioning Strategies for Teaching Cognitively Rigorous Curricula

Gerlinde W. Olvera*
John R. Walkup*

* The Standards Company LLC, 575 W. Alluvial Ave., Clovis, CA 93611

Source URL: http://www.standardsco.com/publications/

Depth of knowledge is a common measure of rigor used extensively at the state level to align assessments with state content standards. However, the use of depth of knowledge at the classroom level is just beginning. In this article, we establish a link between depth of knowledge and the questioning strategies teachers should consider employing during lessons. The result is a systematic strategy for employing peer-shares and group based activities based on the depth-of-knowledge level of the questions. Should use the strategies presented in this article to develop lesson plans that provide enhanced opportunities for students to engage in critical thinking. (Contains 2 tables and 30 references.)

Keywords: depth of knowledge, questioning strategies, rigor, cognitive rigor

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1. INTRODUCTION

To meet the demand of teaching students higher-level thinking skills, many states adjust their curricula, standards, and assessment analyses by employing the depth-of-knowledge model formulated by Norman Webb[1, 2]. The four depth-of-knowledge (DOK) levels of cognitive complexity, shown in Table 1, embodied within standards and assessment items form an essential component of alignment analysis.

The four depth-of-knowledge levels have not only successfully analyzed assessments and content standards at the state level, they can also act as a strategic vehicle to teach advanced levels of cognition as an integral part of the enacted curriculum.[1] Teachers should therefore clearly understand their role at each of the four depth-of-knowledge levels and plan for best strategies to facilitate student progress in becoming independent and critical thinkers. Consequently, lesson plans should clearly demonstrate the teaching, questioning, and assessment strategies teachers plan to use with each lesson and at each level. Lesson plans

1 Teachers should regard depth-of-knowledge levels as ceilings students may achieve when working on a problem. For example, an item or standard designated Level 3 usually contains Levels 1 and 2 demands as well [2].

should also clearly state expectations of content learning and the depth-of-knowledge level(s) teachers have targeted for their students.

Well-planned teaching strategies and constant teacher metacognition drive student success [3]. Consequently, teachers should continuously reflect upon and use the best questioning strategy for each intended cognitive rigor level in order for students to become successful at solving advanced depth-of-knowledge level problems as well.

Table 1: The four depth-of-knowledge levels formulated by Norman Webb [4, 5].

Level	Description
DOK-1	Recalls facts, information, or procedures.
DOK-2	Uses information or conceptual knowledge, two or more steps, etc.
DOK-3	Requires reasoning, developing a plan or a sequence of steps, involves some complexity, more than one possible answer.
DOK-4	Requires investigation, time to think, and processing of multiple conditions.

2. QUESTIONING STRATEGY

Even the best teaching deliveries deteriorate once student questioning fails to engage students and hold students accountable for their own learning. This article refers to a three-step questioning method teachers can use to engage all students in the classroom and ensure student progress in becoming comfortable employing higher-level thinking skills.

1. *Ask the entire class the question.* Teachers often employ two common, yet ineffective, methods for questioning students: (1) They call on an individual student before asking the question, or (2) they call on volunteers (raised hands). Neither practice provides sufficient wait time; the latter practice allows disinterested or struggling students to disengage completely. For questions to engage the class as whole, all students must think their teacher will hold them accountable for their knowledge. Therefore, teachers should pose questions to the class as a whole, with each student anticipating a reasonable chance of being called upon to respond (which requires that teachers randomly call on non-volunteers) [6, 8, 9].
2. *Choose an effective grouping method*. Education research has established the role group activity plays in learning [10, 11]. In group situations, students have to combine their own prior knowledge and perceptions of how to solve a problem [12] with other students

perceptions, knowledge and intentions [13]. The proper grouping strategy, however, depends on the rigor of the question and the academic abilities of the students.

3. *Choose an adequate wait time*. Education researchers have also established the importance of allowing students time to think before responding to questions [7, 8, 14–18]. Three or more seconds of wait time allows student responses to reflect an increased correctness while the typical "I don't know" responses decrease [18]. As with grouping methods, the ideal wait time depends on the rigor of the question. Fortunately, employing peer shares and group activities goes a long way toward providing adequate wait time.

3. NEED FOR A GROUPING STRATEGY

Planning and executing lessons that instill a rigorous and cognitively challenging curriculum requires well-crafted questioning strategies centered on a strategic selection of grouping practices.

Not all students perform equally well at higher cognitive levels, but can assist the group in other ways while learning from their peers. This allows struggling students to internalize the method for finding solutions to complex problems by taking cues from others better versed in applying higher cognitive skills. English language learners and academically disadvantaged students especially benefit from increased use of groups [19].

Not every student walks into class with a wealth of knowledge gained from home or the previous year, however, so teachers should ensure that they have taught students the basic information needed to respond to higher-level questions. For example, students can rank the causes of a war in importance, and justify their ranking, but only if they understand these causes beforehand. Naturally, this does not mean that teachers should teach students the answers to the higher-level questions they plan to ask, which would drive every question down to the lowest level of rigor.

3.1. Role of the teacher

It may seem natural for many teachers to assist student groups by leading them along solution paths they deem "best." However, such assistance (e.g., hints) can manifest the teacher's methodology at the expense of the students' ability to seek their own solutions. After all,

Table 2: Suggested methods and wait time in relation to the depth-of-knowledge level of the activity.

Level	Suggested method	Typical wait time
DOK-1	Individual student	At least 3 sec, more for ELL or struggling students.
DOK-2	Pair-share/peer-share	Considerably longer than DOK-1.
DOK-3	Formal group activity	On the order of magnitude of ten minutes.
DOK-4	Extended group activity	Multiple classroom sessions

providing possible answers while students participate in formal group settings only teaches students to wait until their teacher spoon-feeds them their desired information, a practice detrimental to teaching students higher-level thinking strategies. Instead, teachers should encourage students to explore various aspects of the problem without presenting students with unwarranted guidance.

Group methods, in essence, value the process more than the answer. Even so, teachers should not necessarily consider all answers equally valid. In physics, for example, a group that comes to the conclusion "objects inherently slow down" after watching blocks slide along a plane has not only failed to understand Newton's First Law, it has reinforced a misconception that the teacher will find difficult to exorcize. To properly guide students towards reasonable conclusions, teachers still need to develop educational goals, coordinate overarching activities, and model expected behavior. Student and group mentoring and the assessing of students' comprehension, as well as their cognitive progress, remains the teacher's ultimate role [20, 21].

4. METHOD

Because wait time and the need for peer/group interaction varies with the rigor of a question, the four levels of depth of knowledge and the grouping strategy expressed in the previous section naturally correlate, as summarized in Table 2.

To clarify the discussion, this section will present sample situations that can occur during the planning stage of typical science lessons. The reader will hopefully find it straightforward to apply the following strategies to their own fields of study.

4.1. DOK-1

Student learning related to DOK-1 relies on the teacher's dissemination of information. Questioning strategies elicit a rote response [22] based on merely recalling, summarizing or clarifying previously taught content. Consequently, DOK-1 thinking skills typically require only individual student involvement; teachers ask their students questions based on their perception of their students' needs [23]. Wait time for answers to DOK-1 questions usually lasts less than 10 seconds (but never less than 3 seconds) [18, 24, 25].

The following think-aloud (in italics) illustrates the thought processes when preparing a lesson plan involving a DOK-1 question.

> "Class, I am going to call on someone in a few seconds to state the first phase of mitosis."
>
> *My question requires nothing more than a rote response. According to Table 2, calling on individual students is the usual method of checking for understanding for this type of question. I could ask them to peer-share, which often helps the English learners in my class, but I don't think this is truly necessary for this question; they either know it or they don't. Placing my students in groups would not be strategic because the question simply is not "meaty" enough to sustain conversation. According to Table 2, I need to wait at least three seconds for students to have a chance to arrive at an answer. I have some English learners in my class, so I will wait at least eight seconds.*

In this example, and in the examples that follow, the teacher first considers the grouping activity suggested in Table 2 by default, but then considers moving to a grouping method involving more interaction when necessary. Although the thought processes displayed throughout this article appear protracted, teachers can employ such a metacognitive approach to lesson planning, that is, selecting a grouping strategy or wait time not out of habit (or because it "seems right") but rather as part of an overtly strategic decision-making process.

4.2. Level 2

At Level 2, students begin to rely not only on their prior knowledge but also to assimilate the knowledge of others, therefore enabling them to create a broader base for solving problems and exploring progressively rigorous solutions [26]. For the most part, teachers remain information providers at Level 2. However, now students will need to infer thoughts on their own by examining, comparing/contrasting, and drawing conclusions from information. Questioning strategies therefore focus on their ability to reorganize material. Question prompts should consider requiring students to explain their reasoning in various forms such as drawing, writing, or oral presentations. The problem or solution to a problem consists of using prior knowledge to establish a solution or path-way [2].

DOK-2 responses require some mental processing, so teachers should consider using prearranged peer-share or a discussion with a neighbor. Peer-shares allow students to rely on and share gained knowledge while developing more complex cognitive skills in students [27]. Peer-shares act as ideal precursors for the larger group projects that play such a vital role in DOK-3 and DOK-4 tasks because they encourage the development of listening, questioning, and paraphrasing skills [27].

Wait time for DOK-2 responses should extend beyond the wait time for DOK-1 questions because these solutions require more time to conjure. Fortunately, peer shares typically increase wait time naturally.

> "Class, I am going to call on someone to tell me the difference between El Nino and La Nina."
>
> *My question, which involves comparing and contrasting, is Level 2. According to Table 2, I should simply ask them to discuss possible answers with their peers for maybe a minute before calling on students to respond. Calling on individuals, with no chance to discuss the answer with their peers, is usually not effective for DOK-2 questions. I could place them in their formal groups, but I think formal groups are unnecessary because I don't think that conjuring the responses to my question requires that much interaction.*

Again, the teacher relies first on peer shares, the default questioning strategy in Table 2. Although the teacher considered the next higher level of grouping complexity—formal groups—she decides against it based on the complexity of the question. (If her students were already in formal groups, it would be more efficient to let them remain so.)

4.3. DOK-3

Teachers mainly facilitate, rather than directly instruct, DOK-3 activities. They guide students towards solutions to complex problems by teaching them to solve and justify solutions to non-routine problems. The teacher's role with DOK-3 activities mirrors the Sherpa's philosophy of enabling, advising, and assisting in difficult environments [28]. Teachers should encourage independent thinking in students, which require questioning strategies to reflect this role[20]. As a result, students solve DOK-3 tasks best in collaborative group situations. At this level, teachers should respect the creativity of the group and allow students to brainstorm, plan, and assemble solutions largely on their own.

Teachers may ask individuals within a group or the entire group to explain their thought processes while reaching a solution. Regardless of which students they ask, teachers must allot adequate wait time for groups to explore the myriad avenues needed to solve DOK-3 problems. Therefore, they should allocate significantly more wait time for DOK-3 activities—on the order of minutes.

> "Class, I am going to have you explain why, and give examples of how, human populations may change and/or migrate."
>
> *Based on what I have taught them so far about the behaviors of human populations, this question is DOK-3. According to Table 2, I should first consider placing them in their usual formal groups and guide them to their responses, allowing them time on the order of magnitude of ten minutes to arrive at a result. I think 30 minutes are sufficient. I could have them peer share, but a short discussion with their neighbors will probably be insufficient for this question.*

In this example, the teacher first considers a formal group setting and assigns 30 minutes for discussion based on the complexity (depth of knowledge) of the activity. The teacher then considers alternative group strategies/wait time, but decides against them.

4.4. DOK-4

With DOK-4 activities, students largely self-direct their own learning, so the teacher's role shifts towards that of a coach/facilitator. At this level, students employ their prior knowledge to organize, plan, and monitor most aspects of solving problems in a task-appropriate way [29]. Activities extend over multiple group sessions. Collaborative grouping and debriefing form integral components of DOK-4 activities—students should explain and justify their chosen pathways as a team.

Although few content standards and state assessments reflect DOK-4 curricula, such challenges foster a deeper understanding of interdisciplinary themes. Assessment allows for multiple measures of mastery and includes students' ability to utilize content knowledge as well as their ability to achieve self-imposed individual and group goals.[30]

> "Class, your project is to design a stunt using what you have learned about Newton's laws, projectile motion, and work-energy."
>
> *This question involves a great deal of planning and assimilation of prior knowledge—clearly DOK-4. Table 2 suggests I consider placing them in their formal groups and allowing them multiple opportunities to reach solutions.*

5. DISCUSSION

Teaching students to employ higher-level cognitive skills will challenge many teachers. The educational community is already reconstructing standards, curricula, and assessments to promote this enormous paradigm shift because it has become clear that the twenty-first century will increasingly require citizens who can think critically and creatively [30]. The twenty-first century job market depends on such skills.

This article mapped each depth-of-knowledge level to a suggested grouping/wait-time strategy. This mapping relied on the cognitive complexity of the activity, which in turn required an appropriate strategy to provide the collaborative discussion and wait time for students for students to successfully respond to the prompt. We can now ask the reader if the converse holds: Is the necessary grouping/wait-time strategy for a given question a signature of its depth of knowledge? For example, should we assign "DOK-3" to any activity that, because of its inherent cognitive complexity, naturally demands a formal-group strategy of (say) ten-minute duration to succeed? At this time, we are not sure that such a two-way mapping is valid.

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