Developmental Testing Service

Critical Thinking Seminar
Assessment Report

July 31, 2004

Critical Thinking Seminar Assessment Results

July 31, 2004

Introduction

Task definition

The task undertaken in this study was to analyze the reasoning of a small sample of the organization's managers before and after they attended a 26-week *Critical Thinking Seminar*, during which participants critically analyzed dilemmas taken from a variety of literary sources. The data were transcribed clinical interviews, designed to explore 4 subject areas: (1) problem-solving, (2) the nature of knowledge (epistemology), (3) the learning process, and (4) the roles respondents play in meetings. Our analyses address three questions:

1. What is the Lectical™ level (cognitive developmental level) at which each respondent performs on each interview?
2. Is there development in respondents' conceptions following their participation in the Critical Thinking Seminar?
3. What are the differences between the conceptions of respondents performing at different Lectical™ levels in each of the subject areas?

Cognitive development

When we employ the term, *development*, we are referring to an increase in the *complexity* and *integration* of thought[1]. Persons do not function at a single developmental level. Subject area, testing conditions, testing modalities, and other features of the testing context have an impact on the developmental level of a performance. For this reason, examinations of developmental progress should be multiple and varied, yielding more of a developmental profile than a developmental score. Development is best understood as a slow process characterized by dips, spurts, and contextual variability[2].

The acquisition of conceptual content, which we call *learning*, is a part of development in the sense that *conceptual elaboration* precedes and supports the kind of increase in complexity and integration that we think of as developmental. An adequate amount of conceptual elaboration is a necessary but not sufficient precondition for cognitive development in any given subject area. Educational interventions can be focused on conceptual elaboration, complexification/ integration, or both conceptual elaboration and complexification/ integration.

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[1] In our academic work, we employ the technical term, *hierarchical complexity*, which refers to the way in which concepts, ideas, or ways of thinking observed at one developmental level provide the basis for new concepts, ideas, or ways of thinking at the subsequent developmental level. For example, it is necessary to understand addition and multiplication as independent ideas—as in 4 + 5 = 9 and 4 x 5 = 20—before it is possible to comprehend compound problems such as (4 + 5) x 3 = 27. Similarly, we find that an understanding of the concept of *honor*—the quality of being honorable or having a good name—requires the comprehension of precursor concepts such as *fair*, *truthful*, and *loyal*. Developmental changes of this kind are referred to as *hierarchical integrations*. For further information about this construct, see:

Dawson, T. L. (in press). *"A good education is..." The development of evaluative thought across the life-span.* Genetic, Social, and General Psychology Monographs.

[2] Fischer, K. W., & Bidell, T. R. (1998). Dynamic development of psychological structures in action and thought. In W. Damon & R. M. Lerner (Eds.), *Handbook of Child Psychology: Theoretical models of human development* (5 ed., pp. 467-561). New York: Wiley & Sons.

Fischer[3] refers to functional and optimal levels of developmental functioning. The functional level is the everyday level at which a person performs without support (guidance, examples, etc.). The optimal level is the level at which a person performs with support. We also think of the optimal level as the highest level at which a person is able to perform in a given subject area. If an individual consistently demonstrates a low amount of conceptual elaboration at his or her optimal developmental level, we recommend coursework focused on conceptual elaboration. If an individual presents with a high amount of conceptual elaboration at his or her optimal developmental level, we recommend coursework focused on creating the conditions for complexification/ integration.

General comments on the *Critical Thinking Seminar*

Research has shown that the most effective developmental interventions employ content that is developmentally appropriate[4] and immediately relevant to the experience of learners[5]. This is because it takes repeated experience and practice for skills like *critical thinking* to become generalized. Consequently, it is unlikely that new skills learned in the context of analyzing dilemmas from literary sources will transfer readily to the analysis of workplace dilemmas (unless these skills are already well-developed in the workplace context). Research indicates that the most effective way to promote the development of critical thinking is (1) to employ content that is familiar and immediately relevant to the contexts in which the skill will be applied; and (2) provide opportunities for participants to reflectively apply the targeted skills in less familiar contexts. We discuss this further in the *Recommendations* section of this report.

Method

Twenty probed, semi-structured, clinical interviews were conducted for the pre-assessment and 15 were conducted for the post-assessment, providing us with a total of 15 pre and post assessments. At the time of the study, all respondents were working at the M2 management level.

The interviews consisted of an epistemology dilemma, a problem-solving dilemma, questions about the nature of learning, and questions about the roles respondents play in work-related meetings. The interview form is shown in Appendix A.

The first three interviews were transcribed and submitted to three types of analysis. First, they were scored with the Lectical™ Assessment System, DTS's cognitive-developmental assessment system, which is employed to determine the cognitive developmental level of texts. Lectical™ raters were blind to the pre and post status of the interviews and the management level of respondents. Lectical™ phase scores for each subject area ranged from 23 to 31, corresponding to management level standards as shown in Table 1.

The distribution of Lectical™ levels in this management sample is somewhat inconsistent with the cognitive complexity demands of M2 management positions as described in the standards. A slight majority of the respondents generally perform at Lectical™ levels that correspond to M2 and M3 criteria. This means that almost half of the participants fall below the requisite level, at least within the context of the interviews conducted for this study. Figure 1 shows the mean Lectical™ scores for pre and post assessments of epistemology, problem solving, and learning. The Lectical™ range for the M2 management level is also indicated in

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3 Fischer & Biddel, 1998.

4 We recommend that the level of the material presented should be at the highest level at which an individual performs (on the same subject-matter) with support. By this we mean the level at which the person performs when provided with some degree of assistance in the form guidance, examples, etc.

5 Learners are aware of the importance of relevance. See the descriptions of conceptions of learning in Table 7 and Appendix D. See also:

Detterman, D. K. & Sternberg, R. J. (Eds.). (1993). *Transfer on trial: Intelligence, cognition, and instruction*: Ablex Publishing Corp; Norwood, NJ, US.

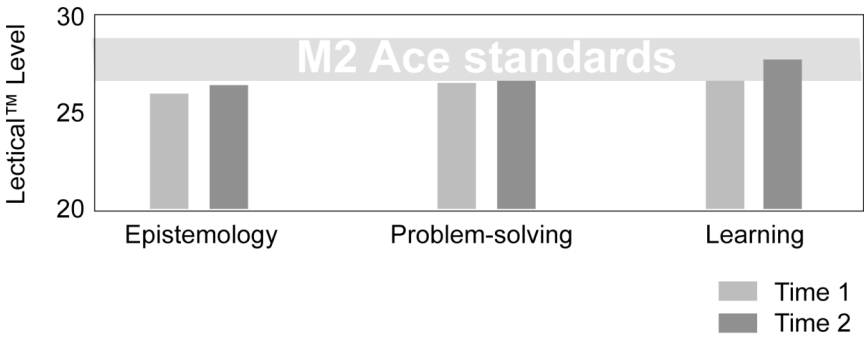
this figure. The mean Lectical™ scores in every condition except the *post* learning condition are below expectations for a group of M2 managers.

Assuming that the performances we evaluated for this study represent respondents' developed capabilities, there is a clear need for the improvement of cognitive skills in the epistemology and problem-solving subject areas.

Table 1: Distribution of respondents by Lectical™ phase (with corresponding management level, as described in the management standards)

Standards	Lectical™ phase range	Epistem-ology		Problem-solving		Learning	
		Pre	Post	Pre	Post	Pre	Post
M0	<24.00	2	1	0	0	0	0
M1	24.00–26.49	5	6	8	6	4	0
M2	26.50–28.99	8	7	7	9	9	13
M3	29.00+	0	1	0	0	2	2

Figure 1: Mean scores for the pre and post assessment conditions



After they were scored, the pre and post interviews were compared in terms of (1) Lectical™ development and (2) conceptual development (method described below). Finally, the interviews were subjected to content analyses to examine changes in conceptions from one developmental level to the next (method described in Appendix C).

The Role interview, because it dealt primarily with descriptions of the roles played by respondents in meetings (rather than reasoning about these roles), was not suitable for a developmental analysis. Consequently, instead of presenting a developmental analysis of the role dilemma, we provide an account of the meeting types and roles described by participants.

Results

Pre and post Lectical™ scores

We conducted two analyses of pre and post changes. The first of these compares Lectical™ phase scores across conditions. Table 2 shows the results of this analysis for each respondent and subject area. There is no evidence of statistically reliable[6] regression in this

[6] Change in Lectical™ score of more than ±1.6 phases. See:
Dawson, T. L. (in press). *"A good education is..." The development of evaluative thought across the life-span.* Genetic, Social, and General Psychology Monographs.
Dawson, T. L., & Gabrielian, S. (2003). Developing conceptions of authority and contract across the life-span: Two perspectives. *Developmental Review, 23*, 162-218.

sample. No one performed at a lower Lectical™ level at the second test time than at the first test time. Moreover, very little statistically reliable cognitive growth (indicated in red bold-face type) is apparent in the epistemology (One respondent moved from a low M1 to a low M2 score.) and problem-solving (One respondent moved from an M1 to an M2 score) subject areas. On the topic of learning, however, 4 out of 15 respondents demonstrated cognitive growth. Of the 4 respondents who demonstrated statistically reliable cognitive growth on the subject of learning, 1 moved from a low M1 level score to a high M1 level score, 2 moved from a low M2 to a high M2 level score, and one moved from an M2 to an M3 score. The mean difference between time 1 and time 2 scores for the learning interview—almost one Lectical™ phase—is statistically significant (t = 2.66, p <.05).

It is unclear why the *learning* subject area produced more evidence of growth than other subject areas. Perhaps taking the Critical Thinking Seminar prompted students to consider the nature of learning. The project manager informed us that most participants experienced an unusually intense positive or negative emotional response to the course as a learning experience. The relation between emotion and cognitive development is complex. A moderate amount of positive or negative emotion tends to enhance development, while a lack of emotional engagement or extreme emotion tends to slow development. It would be interesting to relate participants' course evaluations with their interview results.

Table 2: Lectical™ scores for the pre and post interview conditions by subject area

Case	Epistemology			Problem-solving			Learning		
	Pre	Post	Gain/ Loss	Pre	Post	Gain/ Loss	Pre	Post	Gain/ Loss
1	27.17	28.00	0.8	28.00	28.00	0.0	27.50	28.50	1.0
2	23.50	24.00	0.5	26.00	26.00	0.0	24.00	26.50	**2.5**
3	26.67	26.80	0.1	28.50	28.50	0.0	27.00	30.50	**3.5**
4	24.33	26.50	**2.2**	27.00	27.00	0.0	27.00	27.00	0.0
5	26.67	25.67	-1.0	26.00	26.00	0.0	27.50	28.00	0.5
6	26.75	27.50	0.8	27.50	26.50	-1.0	26.00	27.50	1.5
9	27.17	27.17	0.0	26.00	26.00	0.0	28.00	28.00	0.0
10	27.17	27.60	0.4	26.50	27.00	0.5	27.00	27.00	0.0
11	28.33	29.67	1.3	28.00	28.00	0.0	29.00	28.00	-1.0
12	28.40	27.83	-0.6	28.50	27.50	-1.0	29.50	29.00	-0.5
13	24.20	24.17	0.0	25.00	26.50	1.5	26.50	28.50	**2.0**
15	25.60	25.33	-0.3	26.00	26.00	0.0	25.50	26.50	1.0
16	25.67	25.67	0.0	25.50	27.50	**2.0**	26.50	28.50	**2.0**
19	23.00	23.83	0.8	24.50	26.00	1.5	26.00	27.00	1.0
20	25.00	26.00	1.0	25.00	25.00	0.0	27.50	27.00	-0.5
			0.4			**0.2**			**0.9**

Pre to post changes in conceptions

The themes identified in the epistemology, problem-solving, and learning interviews are shown in Appendix C. As shown in Table 3, our examination of pre to post changes in the number of conceptions found in the interviews reveals no statistically significant change in the number of themes identified in the epistemology and problem-solving interviews. However, there is statistically significant change in the mean number of themes identified in the learning interviews (m = 4.8, t = 2.66, p <.05). The relation between Lectical™ growth and growth in the number of themes presented is not statistically significant, though the 4 respondents demonstrating Lectical™ development also exhibit growth in the number of themes found in their interviews.

Table 3: Number of themes per case for the epistemology, problem-solving, and learning interviews

Case	Epis 1	Epis 2	Diff	Prob 1	Prob 2	Diff	Learn 1	Learn 2	Diff
1	14	14	0	6	6	0	8	10	2
2	10	15	5	6	12	6	7	12	5
3	17	14	-3	8	15	7	3	14	11
4	11	13	2	23	12	-11	6	12	6
5	17	15	-2	16	11	-5	6	14	8
6	12	14	2	10	9	-1	4	21	17
9	12	15	3	11	7	-4	7	12	5
10	17	13	-4	13	13	0	10	11	1
11	16	12	-4	10	9	-1	10	8	-2
12	14	12	-2	11	8	-3	9	12	3
13	11	12	1	9	7	-2	10	22	12
15	12	15	3	10	2	-8	8	19	11
16	13	18	5	12	12	0	9	11	2
19	13	15	2	7	11	4	19	6	-13
20	12	14	2	11	10	-1	6	10	4
			.67			**-1.27**			**4.8**

In-depth analysis of pre and post conceptions

An in-depth pre/ post conceptual analysis was conducted by examining only those conceptualizations that followed the central probes in each interview. This method was adopted for two reasons. First, the interviews were conducted by individuals with different interviewing styles. This resulted in substantial differences between some of the interviews in terms of length, detail and focus—differences that had little to do with the respondents' capabilities. To counteract this we narrowed the analysis to the standard probe questions, which were consistent from interview to interview. Second, narrowing down the analysis in this way made it possible to develop consistent coding criteria for three categories: *conceptual development*, *conceptual elaboration,* and *conceptual shift*.[7] These three categories are defined as follows:

Conceptual shifts

Changes were coded as *conceptual shifts* when the respondent (in response to a standard probe) expressed different concepts in the second interview than in the first. In

[7] Note: by narrowing the focus of this analysis, we make it impossible to compare the results of the analysis of number of themes identified in the interviews with the results of the in-depth conceptual analysis.

other words, some conceptions expressed in the initial interview were entirely absent in second. For example, a conceptual shift on the theme of *scientific inquiry* might involve an initial conception of how economic interests influence the results of scientific studies and these conceptions could be *replaced* by a conception of the ways in which statistical methods can be used to skew the results of studies. This is an example of a conceptual shift *replacing* a focus on the economic factors in scientific inquiry with a focus on statistical methods.

Conceptual elaborations

Changes were coded as *conceptual elaborations* when the respondent supplemented certain conceptions with others not previously expressed. That is, this code was applied to those cases in which the respondent expressed conceptualizations in the second interview that served to supplement conceptions found in the first, offering further elaboration of a particular theme. For example, a conceptual elaboration regarding the theme, *scientific inquiry*, might involve an initial conception of how economic factors influence the results of scientific studies. This initial insight could then be *supplemented* with conceptions of how statistical methods and political interests also affect the outcomes of studies. This is an example of a conceptual elaboration *supplementing* a conception of how economic factors influence scientific studies with conceptions of how statistical methods and political interests also affect the outcomes of studies.

Conceptual developments

Changes were coded as *conceptual developments* in cases where the respondent demonstrated the hierarchical integration of concepts on a common theme. That is, the category of conceptual development was applied to those cases in which the respondent (in response to a standard probe) expressed conceptualizations in the second interview that integrated concepts found in the first interview to form new concepts. Such integration is accomplished through the formation of an emergent conceptualization that subsumes previously acquired concepts by integrating their meanings within a more abstract meaning. For example, the development of a conception of scientific inquiry might involve an initial conception of how economic concerns, statistical methods, and political interests, as independent variables, influence the outcomes of scientific studies. These variables could then be *integrated* into an overarching conceptualization of bias as a factor in scientific investigations. This is an example of the development of a generalized conception of bias, which involves *integrating* initial conceptions of the effects of economic concerns, statistical methods, and political interests. This *integration* results in the development of an emergent and overarching conceptualization.

Pre and post conceptual changes

Appendix B provides a detailed account of the conceptual change for each respondent in each subject area. Table 4 shows the incidence of conceptual shifts, elaborations, and developments. In every subject area, shifts and elaborations are far more common than developments. Conceptual shifts occur 12 times and are evident in the interviews of 10 respondents. Elaborations occur 21 times and are evident in the interviews of 11 respondents. Developments occur 8 times and are evident in the interviews of 7 respondents.

It is difficult to evaluate the relation between the Critical Thinking Seminar and conceptual change. It is our opinion that at least some of the changes observed had to do with the different interview styles of the interviewers in the two testing conditions. At least two very different interview styles were represented. However, this does not explain all of the observed changes, which implies that participation in the seminar may have encouraged some participants to consider more variables/ perspectives in their arguments, or to describe their conceptions more fully.

Table 4: Conceptual shifts, elaborations, and developments for the (1) epistemology, (2) problem-solving, and (3) learning interviews

Case	Shifts				Elaborations				Development			
	1	2	3	Total	1	2	3	Total	1	2	3	Total
1			X	1	X	X	X	3	X			1
2	X			1		X	X	2			X	1
3	X	X		2	X	X	X	3			X	1
4				0	X			1				0
5	X			1				0				0
6				0	X		X	2				0
9				0	X		X	2				0
10	X			1				0				0
11			X	1	X			1	X			1
12		X		1				0				0
13				0			X	1			X	1
15	X			1	X		X	2				0
16				0		X	X	2		X	X	2
19		X	X	2	X	X		2	X			1
20		X		1				0				0
Total	5	4	3		8	5	8		3	1	4	

Role interview: Meeting types and roles

Meeting type: Respondents referred to 7 meeting types, as shown in Table 5. In the initial interview, individual respondents reported participating in from 1 to 5 different meeting types (Mean = 3). We found no clear relation between the meeting types in which respondents reported participating and Lectical™ level.

Table 5: Meeting types mentioned in the Role interviews, with frequency of occurrence

Meeting type	Number of occurrences
Informational/ briefing/ technical/ educational	20
Staff	14
Planning	11
Decision-making	10
Brainstorming	7
Business	6
Informal	3

Roles: Respondents referred to 15 roles, as shown in Table 6. In the initial interview, individual respondents reported taking on from 2 to 8 different roles (Mean = 5). We found no clear relation between the roles reported by respondents and Lectical™ level in any of the subject areas.

Table 6: Roles played in meetings with frequency of occurrence

Role	Number of occurrences
Supply information	20
Receive information	20
Listen/ observe	20
Facilitate	14
Participate/ contribute	14
Lead	11
Identify the right people to work on a problem	10
Make decisions	9
Direct	9
Keep records	8
Act as a conduit for information	7
Guide	5
Act as an expert	3
Filter information	2
Negotiate	1

Subject area content by Lectical™ level

We found distinct differences in the conceptions of epistemology, problem solving, and learning at each Lectical™/management level. These conceptions, which are consistent with those already described in the cognitive developmental literature[8], are summarized in Table 7 and elaborated in Appendix D.

[8] Dawson, T. L. (2004). Assessing intellectual development: Three approaches, one sequence. *Journal of Adult Development, 11*, 71-85.
Dawson, T. L. (in press). *"A good education is…" The development of evaluative thought across the life-span*.
Dawson, T. L., & Stein, Z. (2004, June). *Epistemological development: It's all relative.* Paper presented at the Annual Meeting of the Jean Piaget Society, Toronto.
Kitchener, K. S., Lynch, C. L., Fischer, K. W., & Wood, P. K. (1993). Developmental range of reflective judgment: The effect of contextual support and practice on developmental stage. *Developmental Psychology, 29*, 893-906.

Table 7: Descriptions of the concepts identified at 4 developmental levels

Lectical™ level	Manage-ment level	Epistemology	Problem-solving	Learning
22.75 – 23.99 (AM)	M0	At this level, truth/ reality is what has been scientifically proven or is a matter of personal belief or opinion. *Research* is gathering data, facts, or information, which are used to prove things. Anything can be proven if enough research is done, although some questions may not be researchable (religious questions and/ or questions regarding human nature and emotion). There are better and worse ways of doing research. Experiments are described in simple terms.	At this level, problem-definition is guided by the goal or intended outcome of the problem situation. Unbiased expertise and scientific knowledge are valued. There is a need to differentiate between fact and opinion. Different people have different skills and views relative to a given problem. It is necessary to initiate discussion so that the problem can be understood and solved.	At this level, learning is the way in which one gains understanding. Its function is to facilitate success and self-improvement. The learning process is the acquisition of new knowledge that can be applied, or something that happens during everyday life, during engaging classroom lessons, or through hands-on-activities.
24.00 – 26.49 (AM-AS)	M1	At this level, truth/ reality is what is certain scientifically or in everyday life, or is dependent upon perceptions or interpretations. There is an increasingly clear distinction between *scientific* and *social* truths/ realities. The latter are more influenced by worldviews/ perspectives. *Research* encompasses a variety of ways of gathering information (data or facts) about an issue or question. Sources of information are categorized as more or less biased/ unbiased, scientific/ unscientific, or reliable/ unreliable. The idea of *evidence* is emphasized more than the idea of *proof.* The scientific method (experimental design) is well understood and valued.	At this level, problem-definition is guided by concerns about long- and short-term goals, risks, and benefits. Problem framing, which involves seeking out alternative perspectives during the problem definition phase, directs data gathering. The evaluation of data is guided by the necessity to have the most comprehensive perspective possible. A number of procedures are suggested as ways to verify the quality of factual and technical types of data, while verification of other types of data depends upon unbiased input from individuals. Discussion is seen as a valuable tool in the interpretation and validation of data.	At this level, learning facilitates the expansion of knowledge, increase of intelligence, increase in the ability to solve problems, and modification of one's perspective. There is an emerging notion that learning can benefit society. It is valuable in and of itself. The learning process involves increasing one's knowledge base by gathering information that can be connected with something already known, or by providing insight. Active inquiry and self-reflection are valued.
26.50 – 28.99 (AS)	M2	At this level, truth is the sum of all that has been proven through the use of appropriate methods (relative to particular perspectives). This results in biases that render truth/ reality context dependent and divided into two domains: one that is scientific, another that is social (what is collectively interpreted as being the case). *Research* is a process of investigation	At this level, problem-definition is guided by concerns with clarifying possible processes for planning and implementation. The relative importance of long- and short-term goals, risks, benefits, contributing factors, and possible consequences are considered. Source-specific criteria are applied to considerations of the validity of data. Facilitated	At this level, learning is the process through which knowledge and insight are gained, facilitating the acquisition of new abilities and perceptions of the world. Its function is to promote personal development and the proper and improved functioning of organizations. It is pursued to satisfy curiosities and interests. It facilitates the broadening of perspectives

Lectical™ level	Manage-ment level	Epistemology	Problem-solving	Learning
		that ought to be differentiated according to the procedures used in different forms of inquiry. There are two very broad domains of research and inquiry, distinguished as those things that can be submitted to the scientific method and those that cannot.	discourse is employed to reconcile divergent views. This involves arriving at a new view that integrates the perspectives of the individuals involved. It is important to identify the individuals who possess the requisite skills for providing these perspectives.	and the richness of intellectual pursuits. The learning process integrates new knowledge into an existing knowledge base. It is aimed at gaining problem-solving capabilities and perspectives and insight regarding one's self and others. Dialogue and communication are important ways to learn, since they make others' perspectives more accessible.
29.00+ (AS-SP)	M3	At this level, truth is dependent upon systems of belief and inquiry. Reasoning at this level attempts to integrate a social and perspectival conception of truth with a scientific and evidence-based conception of truth. *Research* is a process of inquiry carried out in order to become certain of the validity of particular conclusions. There is an attempt to explicate a general conception of what constitutes the validity of research that subsumes both scientific and non-scientific procedures for generating certainty. Attempts to bridge these two domains point towards conceptions that explain research as a process that makes it possible to cope confidently with reality and yet remain open to new insights and data.	Unclear due to lack of data.	At this level, learning is the process through which individual and social development proceeds. It is crucial to the evolution of individuals and organizations, as it helps create and implement procedures to generate new knowledge by integrating existing knowledge. It also increases capabilities such as interpersonal skills and aesthetic nsight. Its function is to promote autonomous thinking in individuals, who can then inform the direction of societal learning processes. Learning is valuable because it is one of the basic ways in which both individuals and societies can be improved and problems solved. The learning process is conceptualized as the pursuit of knowledge itself. There is an attempt to integrate problem-based knowledge acquisition models of learning with experientially rich self-development models of learning.

Recommendations

Curricula and assessments

Interestingly, only three respondents referred to the course in their follow-up interviews, despite prompts to discuss classroom experiences in the learning interview. Respondent number 10, who demonstrated no Lectical™ or conceptual growth, stated:

> *I saw that the real value in that…class was the discussion itself, you know, engaging everybody, getting the different viewpoints, understanding some things about expertise,*

> *[for instance] that you don't have to have a credential in order to say something valuable to add to the group.*

Respondent number 16, who demonstrated Lectical™ development and conceptual elaboration in both the problem-solving and learning subject areas, stated:

> *I definitely have answered some of these differently than before, just through the experience the class itself, because listening to a group discussion forces you to…be aware of others a little more.*

Respondent number 11, who demonstrated conceptual elaborations and development in the epistemological domain, provided the following comment:

> *The tricky thing, then, is to find ways to introduce the same concepts that you theoretically have learned…into something that has nothing [to do with text, art, or making comparisons].*

From these comments, it seems like the main thing the first two respondents took away from the course was a new awareness of the importance of the perspectives of others. This is a valuable insight, but, as the third respondent argues, it is difficult to see how to translate the concepts learned in the context of the course to applications in the real world.

The results of our analyses suggest that the Critical Thinking Seminar was not associated with much Lectical™ development. This is not a surprising result, given the slow rate at which this type of development generally occurs and the nature of the intervention. What is more surprising is that there wasn't more conceptual growth in the form of conceptual elaborations. Only 6 out of 15 respondents provided evidence of conceptual elaboration in more than one subject area.

The current cognitive developmental literature suggests that curricula are made more effective when:

1. Learning objectives are clearly defined;
2. They are solidly connected to the contexts in which participants function on a day-to-day basis. This means that skills should first be built in task domains in which they will be frequently applied;
3. They are based on a solid understanding of conceptual development in the targeted domain, paired with expert knowledge of what is important to know in that domain;
4. If there is a gap between participants' functional (unsupported) Lectical™ scores and their optimal (supported) Lectical™ scores in the targeted task domain, instruction should focus on developing and practicing concepts and skills at the optimal level;
5. If there is no gap between participants' functional (supported) Lectical™ scores and their optimal (supported) Lectical™ scores in the targeted task domain, instruction should focus on developing and practicing concepts and skills at the subsequent developmental level;
6. New skills should be practiced. The generalization of a skill is much more likely if there are multiple opportunities for practice. Homework that requires the application of new skills to real-world contexts is an ideal opportunity for practice;
7. Conscious reflection on a newly learned skill helps to make it part of one's repertoire and aids in generalizing the skill. Journaling with constructive feedback from the instructor and class discussions about participants' experiences applying a new skill are valuable reflective activities;
8. Instructors recognize that the application of a new skill is dependent upon factors beyond students' understanding of the skill. Emotional, social, and contextual factors can affect the application of any skill;
9. Learners receive accurate, constructive feedback on their own developmental progress; and

10. Subsequent coursework builds on learned skills and concepts.

We do not know how many of these conditions were met by the Critical Thinking Seminar.

Future research

Given the expense of educational interventions like the Critical Thinking Seminar, we strongly recommend that the instructional objectives of such courses be stated explicitly before implementation, so that it is possible to conduct targeted assessments of their efficacy. We further recommend ongoing assessments of developmental progress prior to and following all educational interventions. Long-term longitudinal assessments can provide information that will, in time, provide a solid basis for matching learners with curricula, saving money and time. We are developing practical on-line assessments of this kind.

The content and form of most curricula are based on the knowledge of domain experts. We recommend considering an additional factor—the way people actually learn the conceptual content and skills relevant to a given knowledge domain. An understanding of the way in which concepts and skills are acquired can be combined with learning objectives identified by experts to inform the creation of more effective, developmentally appropriate curricula.

Appendix A: Interview format

Reflective judgment interview: Television violence

Psychologists disagree about the impact of violent television on children. One group argues that the evidence suggests that television violence causes children to engage in violent behavior. Another group argues that the evidence suggests that television violence prepares children for the realities of adult life, much like fairy tales did before the invention of television.

What do you think of these statements? Have you formed an opinion on this issue? How did you come to take this position?

How is it possible that scientists come to such contradictory findings?

What is the ideal way to go about forming an opinion on a problem like this one?

Can you be certain that your conclusions are correct? Why or why not?

You have used the term reality/ truth/ facts. What does reality/ truth/ facts mean to you?

How do you know when you have identified reality/ truth/ facts?

Do you think there are any absolute truths? Why or why not?

Meetings interview

What kinds of meetings do you attend? Do you play the same role in all of these? Which are the two most important/ common roles you play in meetings? Is your behavior in meetings something you have thought about in the past?

Role 1: Tell me what you are like at meetings in which you play this role. Tell me more. What do you think is appropriate behavior for someone who plays this role? Why?

Role 2: Tell me what you are like at meetings in which you play this role. Tell me more. What do you think is appropriate behavior for someone who plays this role? Why?

Repeat

Learning interview

What does learning mean to you? (Describe your experience of learning?) Tell me more…

How do you learn best? Why do you think you learn best when…?

Expertise dilemma

An outside contractor has been hired to introduce a particular suite of computer-aided software engineering (CASE) tools to SED, Software Engineering Division. The SED engineers responsible for implementing the suite of tools are concerned that implementation within the existing infrastructure over entire project lifecycles will be difficult. A committee has been formed to discuss potential obstacles. Three individuals are at the meeting, the SED engineer responsible for testing and maintenance, the Chief/ SED who views CASE as a leading-edge advance for software design, and an MIT professor who has written several books on CASE and has considerable international consulting experience with CASE implementation.

Which of these experts is most likely to be able to provide a balanced perspective on the implementation of the design? Why?

What is the best approach for the committee to take in attempting to resolve the implementation problem? Why?

Appendix B: Pre-post conceptual analysis

Epistemology

Case 01: This respondent demonstrates conceptual elaboration and development. In the second interview, there is an increase in the number of concepts. A number of new concepts are found in the second interview, including arguments about statistical bias, childhood development, and the notion of testing opinions against evidence. Conceptual development is demonstrated when the insights into the methodological shortcomings of psychology found in the initial interview are developed into full-blown conceptions of scientific methodology. It should be noted that during the second interview the respondent was asked more questions than in the first

Case 02: This respondent demonstrates conceptual shifts. In the second interview, the conceptions of experts and scientific processes are novel. Yet, the addition of these concepts is balanced by the subtraction of others, which is why a conceptual shift is evident and not a conceptual elaboration. In the first interview, conceptions that express relativism via the idea of *opinions* are emphasized, while these conceptions are not found in the second interview. Instead, there are conceptions about expertise and the notion that some facts are true because they are proven, while others are true because they are accepted as true.

Case 03: This respondent demonstrates conceptual shifts with slight conceptual elaborations. In the first interview, there are several conceptions about the differences between qualitative and quantitative data, where quantitative data are taken as capable of making good on validity claims. These conceptions are replaced by more precise discussion of facts, knowledge, and expertise in the second interview. A conceptual elaboration is evident in the conceptions of (a) bias in the sciences and (b) the uncertainty of knowledge. In both cases, the initial conception is expanded and complexified with more specific terminology and elaborated distinctions and explanations. It should be noted that the second interview differs substantially in length and content from the first due to the interviewer's questioning style, although the deep structure remains essentially unchanged.

Case 04: This respondent demonstrates conceptual elaborations. From the initial interview to the second, an insight on the effect of scientific hypotheses on research is elaborated upon, as the respondent considers the need for control groups to insure objectivity. Initial insights into the nature of opinions and opinion formation are elaborated upon in two new conceptions about opinions. An initial insight into the indeterminacy of certain kinds of problems is elaborated into a more complex conception of the distinction between hard and soft sciences. One conception of facts remains essentially unchanged, while a unique conception of facts does appear in the second interview. Conceptions of relativism remain essentially unchanged.

Case 05: This respondent demonstrates a conceptual shift. The majority of the main concepts expressed in the first interview are found in the second interview, in basically the same form, such as conceptions of bias as a result of preconceptions and conceptions that relate the uncertainty of knowledge with the necessity for it. In the initial interview, there was a conception about different kinds of truth (i.e., hard and soft sciences). This conception is not found in the second interview. Instead, there is an elaborated conception of what reality is, which mentions the proof provided by sensory data (hard sciences), but not by the softer forms of data/ reality.

Case 06: This respondent demonstrates conceptual elaboration. In the initial interview, there are several conceptions regarding the context-dependent nature of truth and certainty; these conceptions are elaborated to also include the concept of perspective. An initial conception about the difference between types of truth is elaborated upon to consider the difference between belief and scientific rationality. The conception about differences in scientific conclusions remain unchanged across interviews, as does the conception that knowledge should be revisable in light of future data.

Case 09: This respondent demonstrates conceptual elaborations. An initial insight regarding the need for multiple resources and perspectives is elaborated to outline different resources and

emphasize their importance. An initial insight about the indeterminacy of truth in relation to data from future research is elaborated within various contexts and related to several ideas. Also, an initial insight about the relativity of truth due to different perspectives is related to the inconclusiveness of truth claims.

Case 10: This respondent demonstrates conceptual shifts. Only one concept present in the first interview is present in the second. Instead, a shift toward the conceptualization of truth in terms of instinct and feeling is present. Furthermore, conceptions in the second interview are slightly less elaborated and complex than conceptions found in the initial interview.

Case 11: This respondent demonstrates conceptual elaboration and development. An initial conception about the effect of political and economic concerns on scientific studies is integrated into a more developed conception of the process of scientific inquiry. All of the conceptions in the second interview demonstrate a more developed capacity to discuss and elaborate upon epistemological ideas than do the conceptions present in the first interview.

Case 12: This respondent demonstrates no significant changes. The second interview is longer because the respondent explicates a greater number of concepts, which appear to be unique conceptualizations. However, the concepts that appear in both interviews are consistent enough in their composition to justify the claim that no changes in deep structure are occurring.

Case 13: This respondent's performances are not valid for this analysis, due to a lack of content in the initial interview.

Case 15: This respondent demonstrates slight conceptual elaboration and conceptual shifts. In the initial interview, the respondent attributes contradictions in scientific findings to inconsistencies in sampling, while in the second interview this idea is elaborated upon to consider that bias can result from such inconsistencies. An elaborate description of facts is present in the second interview, but is not present in the initial interview, demonstrating a conceptual shift.

Case 19: This respondent demonstrates conceptual elaboration and development. The initial interview yields only a conception about the uniqueness of individual opinions. The second interview yields conceptions that demonstrate a variety of epistemological conceptions, such as conceptions about facts, scientific inquiry, and a highly developed explanation of the ideal process with which to form an opinion. This conception demonstrates a *form* of reasoning that is more developed than anything in the initial interview. Also present uniquely in the second interview is the coordination of a system of ideas within a single conception.

Case 20: This respondent demonstrates no changes. All the conceptions found in the first interview are also found unchanged in the second.

Problem-solving

Case 01: This respondent demonstrates conceptual elaboration. In the initial interview, the respondent explains that each expert has an important perspective, yet concludes that one individual would have to filter all the perspectives to prescribe an appropriate action. This approach again is adopted in the second interview, accompanied by a more complex account of the ways in which the experts might cooperate to solve the problem.

Case 02: This respondent demonstrates slight conceptual elaboration. In the initial interview, the respondent considers a plan to evaluate the worth of the three experts. This plan is unclear and does not appear to be connected to the skills of the experts, which are described independently later in the interview. In the second interview, the respondent describes how the knowledge of each expert might inform the decision-making process. One expert is chosen as the leader, but all of the experts are considered to have something to contribute to the decision-making process.

Case 03: This respondent demonstrates conceptual shifts and elaborations. In the initial interview, the respondent concludes that one expert should be chosen as the decision-maker for the group, running a meeting and making a decision informed by the perspectives of the other experts. The decision-maker is chosen for specific abilities. In the second interview, the decision-maker is chosen based on a lack of bias, and this expert gains buy-in and consensus from the other experts during a meeting, a process that is described in some detail (a conceptual elaboration from the first interview).

Case 04: This respondent demonstrates no substantial changes. In both interviews, the respondent coordinates the perspectives of all of the experts and makes a decision based roughly upon the same criteria. The first interview did yield some unique concepts due to the detail of the questions asked.

Case 05: This respondent's performances are not valid for this analysis. The initial interview is off-topic and therefore cannot be compared with the second.

Case 06: This respondent demonstrates no substantial changes. In both interviews, the respondent maintains that none of the available experts provides a balanced perspective, since none of them are customers, for example. Both interviews give elaborated conceptions of process, which focus on the planning stages and the steps necessary to insure a successful implementation of the software tools.

Case 09: This respondent demonstrates less elaboration in the second interview but with similar content. In the first interview, the respondent explains that the expert with knowledge of the existing system has the most balanced perspective. The same idea is explained in the second interview, as well. However, in the second interview, the respondent supports this claim with noticeably fewer conceptions than are demonstrated in the first. Likewise, in both interviews it is explained that the process that should be followed is one in which all perspectives are considered; in the second interview, this idea is not as fully explained. It is possible that the respondent's performance is a testament to the interviewers' divergent questioning styles than to changes in the respondent's cognitive behavior.

Case 10: This respondent demonstrates no substantial changes. In both interviews, the same expert and decision-making processes are chosen. In the initial interview, bias is eluded to and abstractly described, though there is no explicit reference to bias. In the second interview, bias is explicitly mentioned. The second interview mentions *buy-in* for decision-making processes, a notion that is implied but not explicitly stated in the first interview.

Case 11: This respondent demonstrates no substantial changes. In both interviews, the same decisions and justifications are made. The first interview is a bit more elaborated, but this seems to be a matter of mood rather than cognitive functioning on the part of the respondent.

Case 12: This respondent demonstrates conceptual shifts. In the initial interview, the complex conception of a closed-discussion-based decision-making process is explained. In the second interview, this concept shifts towards a more open and multi-faceted process. The choice of the expert with the most balanced perspective shifts from a simple answer–that all experts need to be

heard (i.e., that no *one* expert has the most balanced perspective)–to a conception that oscillates between all experts without coming to a clear decision. This is a very slight developmental regression.

Case 13: This respondent demonstrates no substantial changes. While the respondent chooses different experts as representing the most balanced perspective, the reasons for these choices are the same: objectivity and lack of bias. The conception of decision-making in a meeting involving the experts is unchanged between interviews. In both interviews, discussion and debate are chosen in lieu of consensus and voting. Even off-topic remarks are the same in both interviews, such as an elaborated conception of the difference between listening and hearing.

Case 15: This respondent demonstrates no substantial changes. In both interviews, the same conceptions are available for comparison, although the second interview is incomplete. Both interviews reflect the same choice of experts and the same justifications for this choice.

Case 16: This respondent demonstrates both conceptual elaborations and development. In the second interview, the descriptions of the individual with the most balanced perspective are integrated with those in the initial interview, and expanded into more complex and fully-articulated conceptions. In the initial interview, the person with technical expertise is chosen. The second interview maintains this conception, but elaborates on the shortcomings of the other experts and the importance of technical expertise. Conceptual development is demonstrated in the second interview, where conceptions of process found in the first interview are nested within a more abstract and integrated conceptualization of how the experts should proceed in their meetings. For example, the initial interview explains that an outsider with an objective view should be brought into the decision-making process, while the second interview combines this conception with others in order to explain what constitutes adequate decision-framing.

Case 19: This respondent demonstrates conceptual elaborations and shifts. In the second interview, the respondent expands an idea found in the first interview, which represents a conceptual elaboration. In the first interview, the respondent explains that the process of listening to and balancing different opinions is useful, while in the second interview the respondent considers all of the experts' viewpoints individually, but to the same effect. In the second interview, the respondent also chooses a decision-making process other than that found in the first interview, demonstrating a conceptual shift. In the first interview, it is suggested that one of the experts should be consulted, while in the second interview it is suggested that the various factors of the problem should considered. There is some evidence of development, but none suggesting that this is the primary characterization of change.

Case 20: This respondent demonstrates conceptual shifts. In the second interview, the decision-making process found in the first interview is replaced with a different conception. It is explained in the first interview that a clear process should be established and agreed upon, while in the second interview it is explained that one of the experts should identify the issues and that discussion of these issues should follow. All other conceptions remain unchanged between interviews. In the two interviews, different experts are identified as having the most balanced perspective, but the reasons for these choices are the same.

Learning

Case 01: This respondent demonstrates conceptual elaborations and a shift. In the first interview, the respondent considers the importance of discussion to learning, while in the second interview this idea is elaborated into a description of the discussion process. Likewise, in the first interview, the respondent identifies the method of learning through experience as the most effective; in the second interview this idea is elaborated to include reasons for this statement. The conceptual shift appears in the respondent's definition of learning. In the first interview, learning is described as an expanding of horizons, while in the second interview it is described as the acquisition and integration of new facts into an existing knowledge structure.

Case 02: This respondent demonstrates conceptual elaboration and development. However, it should be noted that the differences between the interviewing styles of different interviewers might be the reason for the difference between these two performances. The second interviewer employed more probing questions than the first.

Case 03: This respondent demonstrates conceptual elaborations and development. In the first interview, the respondent defines learning as the comprehension and application of information. In the second interview, these notions are expanded and integrated. In the first interview, the respondent also explains that he/ she learns best by reading and through lectures, followed by application; in the second interview, the respondent elaborates this conception.

Case 04: This respondent demonstrates no substantial changes. In both interviews, the respondent describes learning as an ongoing part of daily life and identifies experience as the chief source of learning.

Case 05: This respondent demonstrates no substantial changes. In both interviews, the respondent provides arguments for learning through experience.

Case 06: This respondent demonstrates conceptual elaborations. In the second interview, the learning method described as the most effective elaborates ideas found in the first interview. In the first interview, the respondent identifies non-theoretical things as what he/ she learns best; in the second interview, this idea is nested within a similar set of ideas about the learning processes through which the respondent learns best.

Case 09: This respondent demonstrates one conceptual elaboration. In the first interview, the respondent explains that learning affects behavior; in the second interview, this idea is expanded upon through considerations of *how* learning affects behavior.

Case 10: This respondent demonstrates no substantial changes. In both interviews, the respondent focuses on personal preferences for specific types of learning situations.

Case 11: This respondent demonstrates conceptual shifts. In the first interview, the respondent takes a theoretical perspective, describing learning in relation to a number of variables, while in the second interview, learning is discussed and described with reference to the Critical Thinking Seminar.

Case 12: This respondent demonstrates no substantial changes. The interviewing styles and questioning probes differ between interviews, but the interviews are nonetheless comparable in content and structure.

Case 13: This respondent demonstrates conceptual elaborations and development. In the second interview, the respondent describes *learning by doing* in a more elaborate manner than in the first interview. Also in the second interview, developmental trends are noticeable in the more complex descriptions of what constitutes learning, such as the expansion of capabilities.

Case 15: This respondent demonstrates conceptual elaborations. In the second interview, the respondent expands upon conceptions present in the first interview, as evidenced in the respondent's explanations of learning by doing. The respondent's conception of learning as sometimes difficult or painful, found in the first interview, is related in the second interview to a conception of learning through failure.

Case 16: This respondent demonstrates conceptual elaborations and development. In the second interview, the respondent gives more complex, abstract explanations of many of the concepts mentioned diffusely in the first interview. For example, the notion of learning through experience found in the first interview is developed into a systematic conception using an expanded knowledge base to solve old problems in new ways.

Case 19: This respondent demonstrates conceptual shifts. The most obvious shift is from the conception of learning through repetition to a conception of learning through imitation.

Case 20: This respondent demonstrates no substantial changes. The respondent explains the same conceptions in both interviews, with an emphasis on the everyday nature of learning and learning through experience. However, the two interviewers' styles differ in their use of probe questions, and it is therefore unclear whether different cognitive behavior would arise if this variance were not present.

Appendix C: Method for detailed analysis of conceptual sequences in development

The detailed conceptual analysis of the epistemology, problem-solving, learning, and role interviews involved two steps, as follows:

First, we read through the interviews, identifying the themes in each content domain. Table A shows the themes identified in the epistemology interviews. After the themes were identified, all of the interviews were coded for their thematic content.

Second, we qualitatively examined the relation between the conceptual content of the interviews and their Lectical™ level, in order to produce descriptions of conceptual differences between levels (shown in Appendix D).

Table A: Epistemology themes

Theme	Description
Absolute truth	There is such a thing as absolute truth
Accuracy	Argues that the accuracy of information should be evaluated
Belief	Refers to the effect of belief on the pursuit of knowledge
Bias	Refers to the effect of bias on the pursuit of knowledge
Cognitive limits	Refers to the effect of cognitive limits on the pursuit of knowledge
Consequences	Suggests considering the consequences of seeking certain kinds of knowledge
Criteria	Refers to criteria for evaluating knowledge
Decision-framing	Refers to the need to frame decisions or be aware of decision frames
Decision-maker	Refers to the role of the decision-maker
Decision-making	Refers to decision-making
Evidence	Refers to evidence
Fact	Refers to facts
Information	Refers to information
Intuition	Refers to the role of intuition in evaluating knowledge
Knowledge	Refers to knowledge
Learning	Refers to the role of learning in the pursuit of truth
Opinion	Discusses the role of opinion in evaluating knowledge
Paradigm	Refers to paradigms
Perspectives	Refers to the effect of perspective on understanding
Proof	Refers to proof
Questioning	Argues that it is important to question truth claims
Reality	Refers to reality
Reason	Refers to the place of reason in the evaluation of truth claims
Reasonable person	Refers to persons as more or less reasonable/ reasoning
Reliability	Argues that the reliability of information should be evaluated
Research	Refers to the role of research in the pursuit of truth
Thought	Refers to the role of thought/ thinking in the pursuit of truth
Truth can be found	Asserts that truth can be found
Truth is relative	Asserts that truth is relative
Truth uncertain	Asserts that truth is uncertain
Validity	Discusses the validity of evidence/ truth claims
Values	Discusses the role of values in the evaluation of knowledge
Wisdom	Mentions wisdom

Appendix D: Detailed descriptions of conceptual development by subject area

Epistemological Theme: Truth/ Reality

This theme represents a central component of epistemological reasoning. It is concerned with conceptions regarding *truth* and *reality*. That is, this theme contains all those facets of a subject's reasoning that address issues surrounding the meaning of *truth* and *reality*.

Lectical™ level	Manage-ment level	Description	Exemplars
AM	M0	At this level, truth/ reality is conceptualized in two ways: 1. Truth/ reality is conceived as what has been scientifically proven. This entails an understanding of science as providing the truth, which is basically a set of facts, theories, etc. (However, because scientific theories change, often what is real/ true is unclear.) 2. Truth/ reality is conceived as a matter of belief. This entails an understanding of opinions and beliefs as determining the truth, which is basically what is believed (personally) to be the case. (However, because different people have different beliefs, often what is real/ true is unclear.)	Everything that is coming to my mind is because of my beliefs…. [A] truth is [that] you're born and you die. But, I guess that is because of my beliefs. (20044)

Lectical™ level	Manage-ment level	Description	Exemplars
AM+ to AS-	M1	At this level, truth/ reality is conceptualized in two ways: 1. Truth/ reality is conceived of as what is certain. This certainty is attributed to scientific results or to the unquestioned aspects of everyday life. Uncertainty as to what is true or real is explained as the inverse of these, i.e., ambiguous scientific results or inconsistencies in the experience of everyday things. 2. Truth/ reality is conceived of as being dependent upon perceptions or interpretations, which are based upon individuals' beliefs and opinions. Uncertainty as to what is true or real is explained as the result of conflicting interpretations or perceptions. These two ways of conceptualizing truth/ reality are often related to an increasingly clear distinction between *scientific* and *social* truths/ realities.	I think there are certain truths that are there, and will always be there…. I think there are a lot of facts, and there are a lot of activities that happen as a common sense routine every day. The sun does come up every day, and it will do until some comet or something takes out this earth and we can't see the sun anymore; I think there is a certain truth [to] that…you know, we're going to have four seasons throughout the year. The leaves are going to fall. I mean those are common events in nature that are truths that, typically, are going to happen. That's the scientific side of me. (20072) Reality more is the way things are. [But,] in reality, you're going to have different opinions, and you're going to have people that interpret things differently…it's left to interpretation, and that's reality. Interpretation? Interpretation is my take on things. In other words, given a series of facts or statements, my interpretation is: here's what I believe this means. That's my interpretation. And, I would say my interpretation is different than my…. A conclusion is something that I would do scientifically…something that I would do on the basis of mathematical, mathematical and proof, and all that, and [the] scientific method. And, I say my conclusion here is this: if I'm dealing in the verbal world, you know, with, you know, the political science—like he said, she said, you know, he did this, she did this, what happened at the meeting—then I would tend to say…I would interpret this situation in this way, as opposed to conclusion. (20072)

Lectical™ level	Manage-ment level	Description	Exemplars
AS	M2	At this level, truth/ reality is conceptualized in several ways: 1. Truth/ reality is conceived of as the sum of all that has been proven though the use of appropriate methods. This method is described and justified as being scientific or mathematical. Uncertainty as to what is true or real is the result of inaccuracies or indeterminacies in the method—as lack of data, inconclusive data, or incomplete data. Often, the scientific method is conceived of as a learning process. 2. Truth/ reality is conceived of as being relative to particular perspectives, which are determined by interpretations and perceptions based on beliefs and opinions. These perspectives result in biases that render truth/ reality context-dependent. Uncertainty as to what is true or real is explained in terms of relativism—the idea that different perspectives disclose different realities/ truths, which are equally valid. 3. Truth/ reality is conceived of as being divided into two domains: one that is scientific, another that is social. That is, truth/ reality is conceived of as taking on a different meaning depending upon which domain is in question. This distinction is related to the two conceptualizations described above. When the distinction is elaborated, it is explained that in the scientific domain, truth is what can be proven and verified, while in the social domain, truth is what is collectively interpreted as being the case.	I'm going to answer that from a scientific point of view…. There are knowns, and those knowns are based on proven hypotheses that become theorems that become laws. We base reality on those, from a scientific point of view. And, they're viewed as true, because nobody has proven them incorrect for the time being. (20028) Well, the sky is blue, but my husband is colorblind, so maybe it's not blue to him. To him, he would say that I'm wearing a blue sweater; I say it's gray, or it's charcoal. So, my reality and his reality are equally accurate, but they start from a different perspective and a different context. So, that's what I meant, that a statement of reality, I think, has to be bounded by a context. (20094) Humans live in something that is explainable both by science and belief. The science plays not a small role, but most everything is relative…. There are certain…scientifically provable things like gravity and other things that I would put in the truths category…. But, human relationships, you know, there's far less than provable truth. In that regard, I'm guided more by convictions, or judgments, or experiences, or [by] appreciating different perspectives. Two very different people can see the same act and declare that the truth that would have it is very grossly different. (20058)
AS+ to SP-	M3	At this level, truth/ reality is conceived as being dependent upon systems of belief and inquiry. Reasoning at this level consists of attempts to integrate a social and perspectival conception of truth with a scientific and evidence-based conception of truth. This includes: (1) expanding a conception of relativism based on perspectives, into a conception of relativism based on systems of belief, and (2) expanding a conception of science based on evidence and proof into a conception of science based on an understanding of validity as secured though social practices and consensus. At this level, truth/ reality is that which is both certain and uncertain, because it is multidimensional, serving different functions in different contexts, and requiring different procedures of justification in different domains.	Science seems to be very much evolving. I think certain kinds of knowledge are static—the principles of physics or the principles of how gravity works; certain things that have been mathematically proven, have gained consensus, and have lasted the test of time—I think of [those] as static knowledge. But, I view the world, everything else, [not] as constantly being renegotiated, but re-looked at. I think that all knowledge is open to interpretation, and it's open to revalidation, and it's open to changes in the methodologies by which it is acquired. That is, science is changeable by changes in the perspective of a society, which opens up new ways of understanding…. (1120)

Epistemological Theme: Perspectives

This theme represents a central component of epistemological reasoning. It is concerned with conceptions regarding the nature of *perspectives*. That is, this theme contains all those facets of a subject's reasoning that address how perspectives are implicated in epistemological questions. These include conceptions explaining what constitutes perspectives, and conceptions explaining epistemologically relevant effects of perspectives.

Lectical™ level	Manage-ment level	Description	Exemplars
AM	M0	At this level, *perspectives* are conceptualized as the opinions and beliefs of different individuals. Because different people have different opinions and beliefs, it is difficult to determine the truth about most things. Opinions and beliefs are acquired in different ways, such as upbringing, education, and religion. Scientific facts are understood as being different than beliefs and opinions. This is expressed as an unelaborated distinction between those questions that are matters of belief and opinion and those that are matters of fact.	Truths are what you believe. It's all in your belief. If you believe it, I mean, you know, you get God into the picture, okay; is there a true God? That's everybody's opinion. Everybody has an opinion. You go and read the scriptures; well, everybody has an opinion on what the scriptures say. Everybody has an opinion on why they were written. Everybody has an opinion on who wrote the scriptures. Everybody disagrees, so there's no truth there; you can only read it and then formulate your opinion after you read it. (20219) There are some truths that don't necessarily involve human beings, like scientific truths. But, like I said, all bets are off when it comes to human emotions and those types of things, where it is all a matter of belief. But, yes, there are some scientific truths, I think. (20206)
AM+ to AS-	M1	At this level, *perspectives* are conceptualized as the opinions, beliefs, values, views, and experiences that determine how different individuals see the world. It is explained that, given differences in life-experience and upbringing, different individuals come to have very different views as to what is true. People will inevitably disagree, which makes truth relative to each individual's viewpoint. An elaborated distinction is made between scientific truths (which are not necessarily relativistic) and interpersonal or belief-based truths (which are relativistic). However, it is often explained that bias is common in scientific studies because of the predispositions (e.g., perspectives) that individuals bring to the study.	I do not believe that there are any absolute truths, personally. I don't. I don't believe that. I think that everything is relative. I really believe that. I think that for a person, he could believe that there's an absolute truth, because it's relative to the different people; but, no, I personally don't believe that. When you say an absolute truth, of course, I immediately think spiritually and ethically and all those things that are really kind of intangible and very personal…extremely personal. Two different people could have completely different senses of what truth is because it's relative to them, because of all of those experiences that they've lived. But, like, when I pick up this pen, I know without a doubt it's going to fall when I let it go. Gravity is not relative; it's just a truth, right? So, I guess before when I said no, there isn't any absolute truth…maybe I'll recant that a bit. But, I'm talking from a spiritual—or an ethical sense or something like that—not from a scientific sense. (20210)

Lectical™ level	Manage-ment level	Description	Exemplars
AS	M2	At this level, *perspectives* are conceptualized as complex collections of beliefs and views accumulated by individuals over the course of a unique life history, that determine their understanding and perception of reality. People's perspectives dictate what is true and real for them and as such remain valid even if contradicted by others. Relativism is seen as an unavoidable aspect of epistemological reasoning because of this. Science is usually understood as being biased and/ or relative to the interests and perspectives of the investigators. However, the scientific method is seen as capable of generating truth and facts if it can be insulated from the bias of particular researchers and groups, etc. Additionally, there are emerging attempts to address methods for arriving at agreement and consensus even in the presence of different perspectives.	I would have to look at where the studies came from—if there were any bias to the studies, any perception that was preconceived. I believe that depending upon what your perspective is…you can make the facts paint the story that you want [them] to. So, we need to get to the bottom of the facts. That would be my first step there, to understand where the authority—where the factual interpretation—came from…. So, the perspective is the prism that you focus the data through. It will inevitably affect it. I believe that, depending upon one's frame of reference, data can say different things to different people. The frame of reference, I believe, is where people are coming from. It could be a political perspective, or even their life perspective. The types of issues, things that you've been through, help you view things in a certain way as opposed to somebody who's had different sets of experiences. So, the trick is to be able to communicate within the same frame of reference, and that's the difficult thing, is to get people to the same frame. (881)
AS+ to SP-	M3	At this level, *perspectives* are conceptualized as individual and collective systems of belief and practice. Conceptions at this level explain how a solipsistic and individualized idea of perspectival relativism can be reconciled with ideas regarding consensus and the existence of shared orientations to the world. This is done, in part, by explaining how individual perspectives are nested within cultures and practices that are shared with others. The idea of collective belief systems and the effects that they have on the perspectives of individuals takes prominence. This entails that the relativism that emerges from understanding the irreconcilable differences between perspectives is expanded beyond individuals. Entire groups and ways of life are seen as constituting certain realities that are true for them, and as such remain true even when contradicted by other ways of life.	No clear examples.

Epistemological Theme: Research (inquiry)

This theme represents a central component of epistemological reasoning. It is concerned with conceptions regarding the process and meaning of *research* (or inquiry). That is, this theme contains all those facets of a subject's reasoning that address what research *is*. These include conceptions of how research is carried out and what it generates—i.e., facts, evidence, and validity.

Lectical™ level	Manage-ment level	Description	Exemplars
AM	M0	At this level, *research* or *inquiry* is conceptualized as gathering data, facts, or information, which are used to prove things. It is explained that anything can be proven if enough research is done, although it is suggested that some questions may not be researchable (often these are religious questions and/ or questions regarding human nature and emotion). There are conceptions that there are better and worse ways of doing research. Subjects are able to give simple accounts of what experiments are.	You prove it's true with research, I guess; doing a lot of extensive research…. I'm sure if I did serious research on both issues and made a little chart and weighed it all out, then I might prove it; but, without doing more research, I don't know. (20091)
AM+ to AS-	M1	At this level, *research*/ *inquiry* is conceptualized as encompassing a variety of ways of gathering information (data or facts) about an issue or question. This usually involves a rough taxonomy of sources of information. Furthermore, these sources of information are categorized as more or less adequate, i.e., being biased/ unbiased, scientific/ unscientific, or reliable/ unreliable. The idea of *evidence* is emphasized more than the idea of *proof* at this level, reflecting an understanding that research is not necessarily entirely conclusive. Scientific inquiry is conceived of as one type of research. The scientific method is often explained. It is seen as a particularly authoritative form of research for certain kinds of questions, and as the only kind of research capable of generating facts (and in some cases, proof).	I think in all problems the good way to solve it is to do all the research you can about the issue. Hearing all sides is always the best way, and getting your information from unbiased sources, and just reading as much as you can from different sources and basing your opinion there. (1067) I, you know, I don't know that you can know for certain that you've proven something. You can believe something to be true at a certain time based upon your research, you know, your evidence…but it's subject to change with additional evidence. Many of the things that we deal with are shades of gray rather than absolutes. (719) Since I'm an engineer, I like the scientific method; because, you get facts, and I believe in a lot of laboratory studies—a lot of academic work—that can be backed up as real science. I don't believe in tabloid science, whatever you want to call it…. If you don't understand science or the scientific method, you come up with harebrain[ed] schemes that just aren't real science. (1051)

Lectical™ level	Manage-ment level	Description	Exemplars
AS	M2	At this level, *research* or *inquiry* is conceptualized in general as a process of investigation that ought to be differentiated according to the variety of procedures used in different forms of inquiry. This entails descriptions of which procedures are valid ways of inquiring into particular areas and which are not. Furthermore, there are descriptions of which procedures are more or less valid within a particular area of inquiry—i.e., different types of experimental processes are contrasted, or different ways of gathering information are compared (internet resources vs. academic journals vs. the press). A very general and pervasive differentiation is made in which scientific procedures are isolated and identified as distinct from a complex array of unscientific modes of inquiry. This leads to a conception of two very broad domains of research and inquiry. 1. On the one hand, scientific inquiry is explained in detail as a method that, if followed without bias, will generate valid and reliable results. The scientific method is conceived of as a learning process, which under ideal circumstances (*that are usually not in place*), is capable of effective problem solving and insight into what is the case. 2. On the other hand, a complex domain of inquiry is outlined that is not open to formal and scientific procedures of research. This domain is centered upon human interactions, which are understood as social, communicative, emotional, and psychological. Information, insight, and data about this domain can be gathered, but the criteria by which the validity of conclusions can be assessed are highly ambiguous.	If I'm going to have to make a decision between one of these two findings—you know, about which one is right—then, I'm going to need to look at their analysis, the data that they gathered, and the procedures that they performed on that data; and, I'm going to have to make some judgments based on either the way the data was collected, or the process by which it was analyzed. I'll make judgments on the conclusions that they came to, based on the process they used to get there. (1095) So, you know, I guess just trying to be good about knowing when sources are credible helps you determine what you hear about the world— what might be factual and what might be biased in some way. Of course, it depends upon what [you're] looking into…. As far as a person's credibility goes, [his or her] credibility tends to be sometimes—this is not so well thought-out—it tends to be emotional, but, you know. I don't know. It's certainly better if you know someone over a long period of time, because then credibility can be founded upon whether the person does what he or she says they're going to do. And, you know, we certainly pick up sort of visual clues when we talk to people, in terms of sincerity and also just watching them interact with other people or their environment. I guess sincere is the word, again, [that] I would use. Really, there's no formula, but there is also no replacement for time and interaction with someone before you can establish if you feel they're credible or not. (1022)
AS+ to SP-	M3	At this level, *research* or *inquiry* is conceptualized as a process of inquiry that generates certainty about the validity of particular conclusions. Reasoning at this level attempts to explicate a general conception of what constitutes the validity of research. This general conception is that which is capable of subsuming both scientific and non-scientific procedures for generating certainty. This primarily involves: (1) careful and elaborated conceptions of scientific inquiry that attempt to account for the validity of conclusions reached through the scientific method (which entails elaborated conceptions of bias and other insights into the processes responsible for invalidating scientific results); (2) detailed accounts of how interpersonal and non-scientific conclusions should be reached. This entails explaining both the complexity and	Well, you know, either in scientific research or in management issues, I think it's easy to get feedback from your environment to see if your model is valid. And, you can say that the key to a model is to predict the behavior of processes in the future. So, if you have an understanding of what you think is a fundamental reality, knowing full well it's not entirely correct, then you form a hypothesis, and you say, "well, if this is true, that means that this organism or this process will react this way if we do this thing"—and that's fundamentally what's going on with science and management. We have a mental model of what the organization is, and we say, "you know what? If we added people, efficiency would improve." You know, so it's a hypothesis. A hypothesis is, you know, [what] will happen. If you get that feedback that, yes, indeed, you added people and efficiency improved, that is feedback that

Lectical™ level	Manage-ment level	Description	Exemplars
		relativistic nature of human social realities, and the need, nevertheless, for certainty, validity, and the ability to learn, in order to function in complex social environments. Attempts to bridge these two domains point towards conceptions that explain research and inquiry in terms of an open-ended and inconclusive type of certainty and validity. Inquiry is a process that makes it possible to cope confidently with reality and yet remain open to new insights and data.	your model is probably correct. And, that's why it's important to check the organism to see if it's doing what you said, and that's where learning from mistakes comes in, and all that. (791)