HAMPSHIRE COLLEGE CENTER FOR SCIENCE EDUCATION

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Executive Summary

Hampshire College's Center for Science Education focuses on teacher professional development, curriculum development, and student enrichment programs. The Center also maintains significant research programs on student learning and instructional effectiveness. The Center's work is devoted to promoting learning that persists over time and transfers to new situations in and out of school. Our projects develop the implications of the increasing agreement among teachers and researchers that effective learning involves active concept mastery and consistent practice with inquiry and critical thinking.

Funds from this Department of Energy grant supported four projects that involved outreach for grades 9-12 in under-served school districts:

- *Camp Science Investigators (CSI)*. CSI is a combined professional development institute for science teachers and academic enrichment program for adolescents. Grant funds supported, and allowed us to refine, this ongoing program of the Center during the years 2003-2005. CSI has affected over 1,000 students per year in under-funded, under-served school districts in five areas of the U.S.
- *The Collaboration for Excellence in Science Education (CESE)*. CESE is a partnership with the Springfield, Massachusetts school system to develop physical science curriculum, to foster the professional development of science teachers, and to perform research on student learning in the physical sciences. Grant funds partially supported the planning and establishment of CESE in 2002-03 and its professional development and research programs in 2003-05. During the grant period 10 teachers and over 1,000 students were exposed to the CESE program and curriculum. In addition to its direct service benefits, CESE is structured to generate research data on developmental pathways in science learning. During the grant period, a substantial data set on people's conceptions of energy was generated and analyzed in terms of neo-Piagetian developmental theory. The analysis revealed a developmental sequence that has implications for K-12 physical science instruction and that shows interesting similarities to development in other conceptual domains, such as morality. Papers on the research results appear in three appendices to this report. CESE is an ongoing partnership that will continue beyond the grant.
- *Technology partnership*. The grant supported a partnership in which the School of Cognitive Science at Hampshire shared its expertise and resources in digital technologies with schools and teachers in the cities of Springfield and Holyoke, MA. In a demonstration project Cognitive Science faculty and staff worked with students and teachers in Holyoke to produce video documentaries on scientific/medical topics of community importance. In a one-time curriculum consultation Cognitive Science faculty worked with high school technology teachers and the district coordinator to revise their computer science courses to accord with changing state and national standards.
- *Hampshire College science faculty outreach*. Grant funds partially supported and contributed decisively to the expansion of the ongoing science outreach activities of the School of Natural Science at Hampshire. These activities are focused on local districts with large minority enrollments and will continue in the future.

Accomplishments vs. Goals and Objectives

Each of the four projects supported by the grant met or exceeded its goals. Staff continuity played a major role in this success. At the beginning of the project a senior researcher, Theo Dawson-Tunik, and a science outreach coordinator, Vanessa Paulman, were recruited. They stayed throughout the grant period, with Dawson-Tunik conducting the research on the CESE project, and Paulman providing organizational support and management on all projects. The comparison of accomplishments with initial goals and objectives is broken down below in terms of the four projects that were supported by the grant.

- *Camp Science Investigators (CSI)*. At the time the grant was awarded CSI was an established professional-development program with strong track record. The basic goal of grant funding was to allow the program to continue during the funding period. The grant was also a period of significant refinement for the CSI professional-development model. Progress was made on using videotape to provide continuing support to teachers during the academic years following CSI summer programs, and a new emphasis was developed on using classroom inquiry activities to support state science-education standards.
- *The Collaboration for Excellence in Science Education (CESE)*. CESE was proposed in the grant application as a model for combining professional development and research on learning in university-K-12 collaborations. We succeeded in establishing a strong and enduring partnership with the Springfield, MA school district, its science curriculum coordinator, and its science faculty. The grant-funded project focused on the 9th grade physical science curriculum. It resulted in new curriculum co-developed by project staff and classroom teachers, three years of workshops on teaching and assessment, and substantial new body of developmental research. The hypothesis underlying the research was that the hierarchical complexity theory and assessment procedures developed by Fischer, Commons, Dawson-Tunik, and others could account for developmental sequences in the learning of physical-science concepts. The data supported this hypothesis. Research papers appear as appendices to this report. Other details are viewable at http://cese.hampshire.edu/.
- *Technology partnership*. The technology partnership was also proposed in the grant application. We established partnerships with the Holyoke, MA and Springfield, MA schools, which led to two significant projects. The curricular consultation in Springfield was a successful one-time intervention. It provided the framework and contacts for further work, but none is planned at this point. The video documentary project in Holyoke was a successful proof-of-concept for the use of student-produced videos in science education. Although student photography and video are now widely used in social studies and humanities/arts curricula, their use in science instruction, particularly in a community-based context, is relatively new. We hope to develop this concept further in future work. Unfortunately, instabilities in the Holyoke school system and difficulties with maintaining liaison have made the future of that partnership uncertain.
- *Hampshire College science faculty outreach*. This outreach program was well established prior to the grant and has a national reputation. Grant funds allowed the program to continue and be expanded during the funding period. A professional development institute for K-12 teachers on Rethinking Race was a highly-successful new element of the outreach program that was funded by the grant.

Summary of Project Activities

Camp Science Investigators

Project Description

In 2003, 2004, and 2005 Department of Energy funding partially supported and allowed Hampshire College to expand *Camp Science Investigators* (CSI), a combined professional development institute for science teachers and academic enrichment program for adolescents. CSI participants were from schools with predominantly minority and low-income student populations in Massachusetts, Washington, DC, Durham, North Carolina, and the Mississippi Delta. Each CSI yearly program integrated instruction in science content and science pedagogy. The 2003 and 2004 programs began with week-long summer institutes for 10 teachers, who played the role of secondary students, working intensively to master science content through intellectually accessible and stimulating inquiry activities. The institutes were followed by two-week science education programs for approximately 170 youth. Teachers practiced their pedagogical skills and developing content knowledge under the supervision of mentor teachers, covering content that supported state frameworks in math, science and engineering. Students engaged in challenging, inquiry-oriented activities, e.g. designing, building, and racing hovercrafts, and solving life-like medical mysteries. Assessments of student work focused on content mastery and the understanding of scientific principles. Classroom instructors and mentors reviewed classroom videotapes to reflect on and refine their practices and the educational environment. The 2005 program had the same structure, but its overall length was shortened to 10 days. Following the 2003 and 2004 summers, teachers received continuing support during the academic year through a program of classroom observation and videotaping. Participating teachers presented videos of example lessons to demonstrate their maturing application of the approach used in CSI while at the same time raising questions and concerns about instructional challenges, which were discussed among participants. These academic year sessions served as catalysts for continued development. CSI teachers reached over 1,000 students per academic year.

CSI and its precursor programs were founded on a set of guiding principles: (1) Presenting teachers with models of effective instruction that focus on essential concepts in the sciences and that feature hands-on, inquiry-driven learning activities; (2) helping teachers connect instruction to student learning and to assessment standards that promote complex understanding; (3) developing teachers' instructional skills throughout the school year through sustained, scaffolded practice; and (4) integrating content knowledge instruction with pedagogical instruction in teacher development.

Assessment

The participating teachers responded very positively to the summer program. They saw that teaching and learning could be more effective, more lasting, and more personally satisfying. They showed gains on a pre-post assessment of content knowledge, and classroom observations and videotapes demonstrated clear progress in achieving concept-driven, inquiry-oriented instruction. Student writing and project work showed an increasing ability to use science concepts in inquiry projects, and virtually all students showed gains on the pre-post content assessment.

Participating districts' student populations were primarily non-white and classified as falling below the poverty line. These factors, combined with the limited deep content knowledge on the part of the teachers, contributed to teachers' concerns regarding the viability of inquiry-oriented instruction in their classrooms. Despite this initial reluctance, teachers were receptive to the CSI model of professional development and sustained their commitment to it in the academic years following the summer programs. The impact of the summer intervention strategy was evident in academic year observations and videotaping, although classroom and school reassignments limited observations in several situations. Across communities, teachers' journals and final evaluations consistently mentioned their students' increasing ability to develop hypotheses, articulate and demonstrate ideas, and design experiments to test their maturing understanding.

It should be noted here that CSI teachers work in schools where sustained long-term improvements in instruction are still limited by a number of factors, such as inadequate physical resources, the pressures of managing very large student loads, and short-sighted state-wide testing policies.

Primary staff: Madelaine Marquez, Director of the Center for Innovative Education; Vanessa Paulman, Science outreach coordinator

Collaboration for Excellence in Science Education

Project Description

The Collaboration for Excellence in Science Education (CESE, pronounced *see-see*) was established to provide opportunities for Hampshire College and Springfield high schools to work together to improve student performance in the sciences. CESE is designed to integrate teacher development, curriculum development, and research on student learning.

The program aims to improve teachers' content knowledge in their subject areas and their pedagogical content knowledge. We help teachers develop their pedagogy to be in line with current research on teaching and learning. This research shows that teaching students explicit thinking skills in the contexts in which they will use them greatly improves their achievement. We teach high school science teachers to teach students to

- Describe in words and pictures their own mental models of how/why things work and to use evidence and argument to improve their models.
- Develop their own hypotheses for experiments or explanations for everyday events.
- Write about science ideas.

The project supported by the current grant combined learning opportunities for grade 9 physical science teachers with our own research on students' science knowledge. The results of our research on students' learning are being used to inform our continuing partnership with the teachers and are also being submitted for publication in educational research journals.

During Winter 2003, the CESE team worked with Springfield Public Schools to recruit 10 physical science teachers to participate in the program through the 2004 school year. The participating teachers selected 2 topics of focus: energy and waves. We conducted 3 workshops in March and April of 2003 and a 4-day summer institute in the summer of 2003, designed to teach content knowledge, methods for assessing student understanding, hands-on activities that could support conceptual development, and pedagogical strategies. The institute was also designed as a venue to share initial research findings and to redesign the energy and wave instructional materials in light of experience.

We conducted 3 additional workshops for teachers in the 2003-2004 academic year. The workshops focused on a combination of pedagogy and physics content, and worked to help teachers better use the "teasers" in their classrooms. In the 2004 Spring semester teachers tested the redesigned instructional units, using "teaser" problems to assess student understanding. Over 1,000 students were exposed to the CESE curriculum materials and teaching methods.

Summer 2004 was spent reporting outcomes and assessing the project. The 6 strongest classroom teachers from the original group of 10 teachers were selected for the 2004-05 project. The teachers attended 6 2-hour sessions and one full-day workshop in which the CESE staff worked with them to improve their pedagogy and adapt CESE assessment and instructional strategies to new curricular units. In Spring 2005 teachers videotaped themselves teaching a unit and using "teasers" in the classroom. In several workshops they viewed their video clips and offered peer feedback on teaching, classroom management, use of materials and teasers, and overall pedagogical style.

Research and assessment
Approximately 50 students in CESE physical science classes were interviewed individually about their concepts of energy. All students wrote answers in class to energy "teaser" problems. An additional sample of over 40 younger or older students were given the same interview. The energy interviews were independently scored for developmental level and analyzed for conceptual content. The analyses of the energy interviews were employed to construct descriptions of the developmental progression of energy-related concepts from age 5 to age 16. These descriptions were used to design a scoring rubric for teachers to employ in scoring the energy *teaser* designed during the first year of the project as a data-gathering instrument. The scoring rubric was presented to teachers in August of 2004. Most of the teachers participating in CESE were able to employ the rubric to accurately score a set of teasers filled out by their students. The entire energy lesson designed for this project, including the teaser, the rubric, and a scoring exercise can be found on the web at http://cese.hampshire.edu/. We began scoring and analyzing a parallel set of interviews about waves. This work will continue as a part of future research projects.

In addition to employing our findings to inform assessment in CESE classrooms, we have conducted detailed analyses of the developmental trends in both energy and reflective moral judgment interviews. Four papers are either in review or being prepared for publication. The first of these, "Epistemological development: It's all relative," was originally presented at the annual meeting of the Jean Piaget Society in August 2004. In this paper we show that moral relativism (regarding obligation) begins to emerge as early as 5 years of age and is rooted in early social knowledge, while cognitive relativism (regarding the nature of reality) is rooted in observations about the material world and emerges much later (in review, attached as Appendix A). The second paper, "It has bounciness inside! Developing conceptions of energy," presents an account of the sequence through which energy concepts develop from ages 5 to 16 and describes post-instruction changes in conceptions in a group of 9th graders. This paper includes an extensive review of the existing literature on energy conceptions (in review, attached as Appendix B). The third paper, "A rubric for assessing students' conceptions of energy," presents the energy rubric along with our method for translating research findings into a practical rubric for teachers (in preparation). A fourth paper examines the development of conceptions of leadership (in review, attached as Appendix C).

Primary staff: Laura Wenk, Assistant Professor of Education; Theo Dawson-Tunik, Visiting Assistant Professor of Education and Senior Researcher; Vanessa Paulman, Science Outreach Coordinator

Technology Partnership

In the technology partnership, which extended through the first year and a half of the current grant, the School of Cognitive Science at Hampshire shared its expertise and resources in digital technologies with schools and teachers in the cities of Springfield and Holyoke, MA. Digital technologies are becoming increasingly critical to the school curriculum, and barriers to adoption in under-served districts are contributing to a *digital divide* that separates them from wealthier districts. This project consisted of two components. The first was a demonstration of the use of digital video and web design in project-based science learning, and the second was a series of consultations on the high school computer science and digital media curricula.

Digital video project

In this project we worked with high-school and middle-school students in Holyoke, MA, an under-funded district, training them to make videos and build web sites about asthma, an issue of importance to the local community that has significant science content. The goal of the project was to demonstrate to teachers and community leaders that students will learn both science and technological skills when they are engaged in a project that educates their community on a topic of immediate concern.

The high-school component of the project was a collaboration with the ABE-to-College Transition Project located in Holyoke Massachusetts. The ABE-to-College initiative is a grant-funded program of the Nellie Mae Educational Foundation in partnership with the New England Literacy Council. The goal of this consortium is to assist young adults who have dropped out of high school to make the transition back to school, and then on to college. Dan Knapp, a Hampshire graduate and an expert in developing community-based video, established a consulting relationship with a class at ABE being taught by James Lesko, a local community organizer and teacher. Working over the summer term of 2002, a lesson plan was developed that involved the students in an exploration of the causes of Asthma in Holyoke, Massachusetts. The plan included sections on the environmental and political conditions that lead to asthma as well as the mathematical, research, and investigatory skills necessary to pursue the topic. Students were brought to Hampshire to consult with Elizabeth Conlisk, an epidemiologist and public health specialist on the Hampshire faculty, and with Thomas Plaut, MD, a local, nationally-known asthma expert. Finally, students were instructed in the art of video production, allowing them to storyboard, shoot, create, and edit a twenty-minute piece on asthma in Holyoke.

In the middle-school component of the project a second video on the topic of asthma in Holyoke, was developed. Dan Knapp worked with a group of Holyoke middle school students through an independently funded program known as the Access Holyoke Project, jointly funded by Nueva Esperanza and MCI-WorldCOM (Campus Compact). The Access project was originally designed to teach community-based web development strategies to students in Holyoke with college aspirations. Knapp worked with them on the same methodology that was used with the high school students, and a second video tape, also of approximately twenty minutes, was produced.

At both the middle and high-school levels a credible case was made for the capacity of community-based video production to engage students in the study of scientific questions. The production and problem-based instructional method made science relevant to students who were previously unengaged, and it led them to master new scientific, mathematical, technical, and communication skills. The classroom materials developed for the project are suitable for facilitating similar projects in the future.

Curriculum consulting
In this project members of the School of Cognitive Science at Hampshire consulted with technology staff in the Springfield, MA schools to refine and manage transitions in their technology curriculum. In a series of group and one-on-one meetings between Hampshire faculty and Springfield teachers the focus was on high-school level courses in computer programming and digital media. The teachers and the district technology coordinator faced the problem of maintaining curricular continuity in an environment of changing technology and state/national standards. Hampshire faculty, led by Jaime Davila and Chris Perry, worked with the teachers to define syllabi and lessons that reflected content and learning goals that are independent of the transient details of technology and responsive to the better-motivated aspects of standards. For example, Professor Davila worked with the teachers to develop a programming course that uses student-centered teaching methods to better prepare students for the computer science AP exam.

Primary staff: Steven Weisler, Dean of Cognitive Science and Dean of Academic Development; Dan Knapp, Hampshire alum and video producer; Elizabeth Conlisk, Associate Professor of Health Science; Jaime Davila, Assistant Professor of Computer Science; Chris Perry, Assistant Professor of Media Arts and Sciences.

Science Faculty Outreach

Funds from the current grant enhanced and partially supported the ongoing science outreach activities of the School of Natural Science at Hampshire. The following activities were supported:

Day in the Lab

Day in the Lab (Fall) and *Girls Day in the Lab* (Spring) each bring approximately 130 middle school students from Western Massachusetts to the Cole Science Center at Hampshire for a day to participate in hands-on laboratories led by Hampshire faculty, staff and students. The lab days are designed by the Center for Science Education, the Women in Science Program, and the School of Natural Science to encourage young women and minority students to think about careers in science. Under supervision by Center Staff and Hampshire faculty, Hampshire students offer lab experiences to middle-school students, as well as labs and workshops for teachers and parents that introduce inquiry-based teaching models.

Throughout the period of the grant, from 50 to 80 Hampshire students volunteered each semester to help organize the program or to lead hour-long labs on a wide range of topics in physiology, genetics, chemistry, physics, math, engineering, and anthropology. These events are a valuable experience for the college students involved, and over the past two years volunteers' numbers have increased more than 25%. *Days in the Lab* inspire students to further their own explorations in the sciences and science education, and deepening their commitments to community service.

The Environmental Studies and Sustainability Program Speaker Series

The series brought 10 speakers each year to Hampshire College. Topics ranged from local food initiatives and community supported agriculture to sustainability-focused educational programs and energy efficiency.

NS 288: Inquiry Science Teaching in Secondary Schools

NS 288 was a Fall 2004 course taught by Merle Bruno, Professor of Biology, and Vanessa Paulman, Science Outreach Coordinator. The course provided support and an academic context for Hampshire's science outreach activities. Students examined and evaluated science curriculum materials designed for inquiry-based teaching. They chose one of three projects-- either physics, chemistry, or biology--and worked in teams to develop, implement, and improve activities that support both content learning and inquiry. Projects focused on concrete issues of interest to students such as health, food, and assistive design. A major component of the course had students teaching the activities in local urban schools during a three week period. Many reported that the classroom teaching opportunity helped them understand what it takes to teach science through the inquiry method and enabled them to strengthen their confidence and skills in science and teaching generally. Students in the course were also expected to participate in the Day in the Lab program described above.

Rethinking Race Institute

During the summer of 2004, Hampshire offered an 11-day summer institute called Rethinking Race, where fourteen K-12 teachers had the opportunity to gain in-depth knowledge of current research and controversies in genetics, biological anthropology, human evolution, and history. Among many activities and laboratory experiments participants analyzed and compared their own mitochondrial DNA to that of others in the group and to a large international database as a means of investigating complex patterns of human similarity and diversity. In addition, they considered the historical roots and impact of the concept of race, as well as the health and social consequences of racism.

The teachers had the opportunity to discuss and practice effective, standards-based methods for transferring their experience back into the classroom. Mentor teachers provided feedback and coaching on instructional practices, and dialogue facilitated deeper reflection on ways to integrate learning-centered, inquiry-based instruction into day-to-day teaching practice. The 14 teachers who attended the institute reached over 1,000 students in the 2004-05 academic year.

Primary staff for the above outreach programs; Vanessa Paulman, Science Outreach Coordinator; Madelaine Marquez, Director of the Center for Innovative Education; Merle Bruno, Professor of Biology; Alan Goodman, Professor of Biological Anthropology; Lynn Miller, Professor of Biology; Steve Roof, Assistant Professor of Earth & Environmental Science; Robert Rakoff, Professor of Politics & Environmental Studies.

Appendx A: Collaboration for Excellence in Science Education Research Paper

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, Canada. (Currently under review for journal publication)

The Development of Relativism

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Abstract

In this paper, we employ a methodology called *developmental maieutics* to trace the development of relativism in two samples. The first is a group of 108 children, adolescents, and adults who were interviewed to elicit their conceptualizations of truth in the social and physical worlds. The second sample is composed of schoolboys interviewed about their moral judgments during the 1950s, early 1960s, and 1990s. The interviews of individuals in the first sample were employed to construct a description of the development of reasoning about truth and reality across the lifespan. We found a clear progression in the development of these concepts over the course of the lifespan, with distinctive pathways for reasoning about the material world and reasoning about the social world. The interviews of individuals in the second sample were employed to examine possible differences in forms of moral relativism expressed by adolescent males interviewed in the 1950s and 1990s. We found no evidence of cognitive developmental differences between the moral judgment performances of same-aged adolescents growing up in the 1950s and 1990s. However, we did find evidence of a 4 to 10 fold increase in indicators of moral relativism in the youth of the 1990s. This manifested in two forms, *subjective relativism*—the assertion that right and wrong are relative to personal beliefs or opinions—and *contextual relativism*—the assertion that right and wrong are relative to culture, socialization, or worldviews.

Special thanks to the Murray Research Center for the use of Kohlberg's original data and to Marvin Berkowitz for the use of his data.

The Development of Relativism

In both Perry’s (1970) and Kitchener and King’s (1990) models of epistemological development, the earliest stages of development are differentiated from later stages by an increasing awareness of the uncertainty of knowledge. At the earliest stages, knowledge is viewed as absolute. As development progresses, an increasing awareness of the uncertainty of knowledge produces relativism. In Perry’s scheme, this occurs at Position 4. In Kitchener & King’s system, relativism appears at stage 4. Both Perry’s and Kitchener & King’s research primarily focused on adolescence and adulthood. In the first study presented in this paper, we employ an alternative methodology, *developmental maieuics*, to examine patterns in the emergence of relativism in a sample of interviews conducted with 5 to 57-year-olds.

Next, inspired by two claims made about recent changes in adolescent thinking, we describe a study comparing relativism in the moral reasoning of schoolboys interviewed in the 1950s and early 1960s with moral relativism in the reasoning of schoolboys interviewed in the 1990s. We pose three questions: (1) Are there cognitive developmental differences between the moral judgment performances of adolescents growing up in the 1950s and 1990s? (2) How is the phenomenon of moral relativism manifested in these interviews and how is it related to cognitive development? (3) Did moral relativism increase from the 1950s to the 1990s?

The latter study was inspired by two claims made about recent changes in adolescent thinking. The first of these is the notion that adolescents are somehow smarter today than they were a few decades ago (Howe & Strauss, 2000; O'Reilly, 2000; Strauss & Howe, 1998). The second is that the emphasis on multiculturalism and racial equality that began to take hold during the latter half of the 20th century has led to both greater moral relativism

(Ogilvy, 2002) and increasing fundamentalism (Gardner, 2004) in today's youth. Both of these claims, if they are accurate, have important implications for today's youth.

We begin with a review of the literature on relativism, in which we offer perspectives on different forms of relativism from both psychological and normative frames of reference, and discuss the implications of relativistic epistemologies for decision-making and learning. Next, we indulge a short discussion of the notion that the youth of today might be "smarter" than the youth of previous generations. This is followed by a discussion of our research methodology, *developmental maieutics*. Because there two independent analyses are presented here, we present their methods, results, and short discussions sequentially, finishing with a general discussion of the implications of this research.

Relativism

What is relativism?

It is generally held that there are two types of relativism: *cognitive* and *ethical*. Cognitive relativism is a label given to a variety of views that question the existence of *universal truths*: that facts and truths about the world do not reflect actual realities; that the world cannot be known—there are merely different ways of interpreting it. Ethical relativism, on the other hand, is a label given to a variety of views that question the existence of *moral universals*: that there are no moral principles or guidelines by which everyone is obligated to live; what is ultimately "good" or "just" cannot be determined; and there are different ways of interpreting what it means to be moral.

Though relativism was not articulated and debated much before the mid- to late twentieth century, it is by no means unprecedented in the history of ideas. For example, the ancient Greek Sophist, Protagoras (famous for his dictum, "Man is the measure of all things”), expressed doctrines that could be considered relativistic (Meiland & Krausz, 1982). Historically speaking, however, skepticism—the doctrine that knowledge is impossible—has been more common than the view that knowledge or truth is relative to persons, cultures, societies, or frameworks (Gowans, 2004).

Explicit relativism is a child of modernity. Europeans building colonial empires began to encounter the radical diversity of moral values and worldviews held by non-Western cultures. Unlike previous multi-cultural empires, such as the Roman Empire, the Europeans approached this diversity as an opportunity for introspection. They institutionalized the academic study of diversity, most notably in the field of cultural anthropology. Early anthropology proceeded under the assumption that the Western worldview and ethics (i.e. scientific and Christian) were superior to those found in “primitive” cultures, which were becoming the focus of detailed empirical study. But that changed with the work of Franz Boas and his students (Ruth Benedict, Melville J. Herskovits, and Margaret Mead), who began to articulate influential and convincing arguments in support of relativism (Gowans, 2004). In fact, in 1947, in conjunction with the United Nations debate about universal human rights, the American Anthropological Association issued a statement declaring that moral standards are relative to cultural and societal frameworks, and that there is no way of demonstrating that the values and morals of one society are better than those of another (“Statement on Human Rights,” 1947). This could be considered the birth of moral relativism.

Today, debates on relativism have seeped into almost all fields of inquiry. More important for the focus of this study, however, is the fact that in postindustrial informational societies, forms of relativism have found their way into everyday life. The evidence that relativism is being woven into the web of shared cultural common sense is everywhere (Habermas, 1984, 1987): Multiculturalism is now a curricular agenda in schools; seemingly contradictory scientific claims are debated in the public sphere (e.g. nutrition, global warming, etc.); religious pluralism is the norm; popular culture is imbued with ethnic, regional, and individual diversity; and we are exposed to multiple media sources and perspectives. We are aware that not everyone in the world sees things in the same way.

It is unclear how these trends in diversity are affecting the first generations socialized within this multicultural atmosphere; it is also unclear how to evaluate these trends. The value of relativism seems ambiguous: It leads toward tolerance, learning and diversity, but can also give way to conflict, fragmentation, and confusion.

Psychological research on relativism

Levels of relativism

In the introduction to his renowned book on epistemological development, Perry (1970) described changes in the questions on Harvard examinations from the turn of the 20th century to the 1960s. The percentage of exam questions requiring the consideration of two or more broad frames of reference had grown exponentially; changing, on average, from 10% to almost 50%. In response, he began a study of *relativism*, defined as the ability to view issues from more than one frame of reference, which he argued was a necessary skill for participation in modern society.

Although Perry initially saw the emergence of relativism as a historical event tied to pluralism, education, and expanding communication networks, he also came to view it as a developmental phenomenon associated with increases in the complexity and integration of thought. In the 1960s, he investigated the epistemological conceptions of Harvard undergraduates by examining student reports of their learning experiences in college (Perry, 1970). He found that Harvard students' conceptions of the nature of knowledge grew through nine developmental positions, from the absolutist (or dualistic) position that knowledge is either "right" or "wrong" to the view that all knowledge is relative, and therefore all choices must be made in the face of uncertainty. Subsequent research into the development of epistemological conceptions provided support for this basic sequence (Benack, 1983; Cleave-Hogg, 1996; Clinchy *et al.*, 1977; Kirk, 1986; Kitchener & King, 1990; Knefelkamp & Slepitza, 1976; Kurfiss, 1977; Widick, 1977).

From Perry's perspective, early forms of relativism are less adequate than later forms because they do not allow for the optimal resolution of complex issues. For example, in the form of relativism identified with Position 4 (Table 1), individuals recognize that the world is full of uncertainty and conclude that everyone is entitled to his or her own opinion. For an individual reasoning in this way, there is only one criterion for decision-making: personal opinion. We call this *subjective relativism*. On the other hand, by Position 6, the individual has embraced broader, more encompassing values or perspectives and developed approaches to evaluating knowledge that permit him or her to make informed decisions in the face of uncertainty.

----------------------------insert Table 1 about here----------------------------

Building upon Perry's work, Kitchener and King (1990) conducted a longitudinal investigation of the development of reasoning about "ill-structured" problems—problems without clear answers. They provide evidence for seven stages of reflective judgment, which correspond in definition to Perry's epistemological positions as shown in Table 1.

More recently, Schommer (1998) developed the Epistemological Questionnaire, designed to assess epistemological beliefs. Performance on the four dimensions assessed by the questionnaire—fixed ability to learn, simple knowledge, quick learning, and certain knowledge—have been shown to change with development. The belief that the ability to learn is fixed changes to the belief that the ability to learn is affected by context; the belief that knowledge is simple changes into the belief that knowledge is complex; the belief that knowledge is certain changes to the belief that knowledge is uncertain; and the belief that learning is quick changes to the belief that learning is gradual (Schommer *et al.*, 1997). The direction of change corresponds to the developmental changes in conceptions described by Perry (1970) and Kitchener & King (1990).

Evaluations of truth claims are not necessarily characterized by relativism. In the late 1960s and early 1970s, Kohlberg (Kohlberg, Levine, & Hewer, 1983), who conducted a well known longitudinal study of moral development in a group of private school boys, initially aged 11 to 15, began to observe a form of moral relativism very similar to the *subjective relativism* identified with Position 4 in Perry's scheme. Some of his respondents, who were in their late teens and early twenties at the time, claimed that there was no basis other than personal opinion for making one moral choice over another. Occasionally, a radical form of subjective relativism was observed in the same respondents who had previously taken firm moral positions on a variety of moral issues. The same individuals later relied on less relativistic criteria for making moral choices, such as a universal right to life or notions of social responsibility.

In Kohlberg's sample, most respondents did not exhibit relativistic thinking of this kind, which suggests that subjective relativism is not a universal phenomenon in the development of moral reasoning, This observation is consistent with Perry's (1970) view of relativism as a historical phenomenon, but inconsistent with normative developmental models like Perry's that include subjective relativism as a developmental milestone. It seems likely that subjective relativism would appear more often in some knowledge domains than others, or when individuals are confronted with ill-structured problems. Kitchener and King (1990) purposefully chose to employ ill-structured problems to study epistemological reasoning because they present two positions with bodies of evidence on each side, therefore encouraging respondents to entertain multiple perspectives. In fact, research indicates that relativism develops along different trajectories in different knowledge domains (Kuhn *et al.*, 2000; Redish, 2003; Schommer & Walker, 1995; Wainryb *et al.*, 2004), and that the pathways through which relativism develops are influenced by cultural practices (Gottleib, 2002). There is also evidence that extreme (or radical) forms of relativism may emerge at more than one developmental level in some populations (Boyes & Chandler, 1992; Schommer, 1994).

Perry saw relativism as a late development, emerging during the college years. In fact, the ability to construct multiple abstract frames of reference—the defining feature of Perry's relativism—is an advanced skill associated with highly developed thinking (Armon, 1984; Commons et al., 1998; Fischer, 1980; Kohlberg, 1984). Perry's observation of dualistic thinking in college freshmen provided support for the notion that relativism is a late acquisition. However, subsequent researchers have increasingly reported that they rarely find evidence of dualistic thinking in college or even high school students (Chandler *et al.*, 1990; King & Kitchener, 1994), while other researchers have argued that forms of relativism are evident in childhood and adolescence (Boyes & Chandler, 1992; Wainryb, 1993; Wainryb et al., 2004). These findings raise unanswered questions about the origins of relativism, its definition, and the developmental pace and trajectories of relativistic thinking.

Degrees of relativism

While some researchers have focused on the development of forms of relativism, others treat relativism as an individual trait that can be observed on a scale from less to more (or low to high). The most commonly used relativism scale is the *Ethics Position Questionnaire* (Forsythe, 1980), which is designed to assess the degree of relativism espoused by college students and adults. It includes 10 statements, such as, "Moral standards should be seen as being individualistic; what one person considers to be moral may be judged to be immoral by another person" (Forsythe, 1980). High levels of agreement with statements of this kind are associated with what we call *radical* relativism, which, in all of its forms, involves a rejection of objective criteria for selecting among truth claims. Interestingly, developmental assessments of relativism and its level of intensity are not statistically significantly correlated (Ho et al., 1997), suggesting that a predisposition toward relativism may be unrelated (or related in complex ways) to developments in the complexity and integration of thought.

Relativism, decision making and learning

Relativism has been shown to have a variable impact on decision making. When relativism is assessed on a *developmental continuum* from one epistemological position to another, higher levels are associated with more adequate decision making (Schommer et al., 1997; Schommer-Aikins & Hutter, 2002; Spiro *et al.*, 1988) and better critical thinking skills (Mines et al., 1990). When relativism is assessed on an *intensity* scale, higher levels are associated with less adequate decision making (Furnham & Briggs, 1993; Harvey, 2001; Keller, 1998; Kleiser *et al.*, 2003; Park, 2002; Sivadas *et al.*, 2002; Vitell *et al.*, 1993).

Individuals who exhibit more developed epistemologies are more able to cope with ill-structured problems (Chandler et al., 1990; Kitchener, 1983; Kuhn et al., 2000; Silva & Nicholls, 1993) and demonstrate greater persistence in learning, active inquiry, and information integration (Schommer, 1990, 1994). Therefore, societies have an interest in assuring that the epistemologies of adults are adequate for the learning and problem-solving demands of daily life. Fortunately, epistemologies continue to develop during adulthood, especially when adults are exposed to ongoing education (King & Kitchener, 1994; Pirttilä-Backman & Kajanne, 2001) and when organizational environments are structured to support epistemological development (Cicala, 1997; Mann, 2000; Rechner & Baucus, 1997).

Employers, in particular, have an interest in understanding the degree of relativism held by individual employees. Radical relativism is associated with poor decision-making, particularly in the ethical realm, and may be on the rise in the face of an increasingly complex world. Youths in the current generation may not be equipped with the cognitive tools required to cope with the cacophony of contradictory information to which they are continually exposed.

Generational differences

A smarter generation?

The cognitive developmental research tradition lends moderate theoretical support for the notion that historical circumstance can reach beyond biological and cognitive constraints to speed the growth of intelligence. Though cross-cultural studies provide evidence that the rate of intellectual development is affected by social and educational environments (Colby &

Kohlberg, 1987a; Piaget, 1995), there are also clear biological constraints that influence the rate of cognitive development. Evidence of this can be found in contemporary research correlating cognitive development with changes in brain states (Fischer & Bidell, 1998). This research shows that the process of becoming intelligent is *physiologically* arduous. It depends not only on the experiential educational processes and problem solving we traditionally associate with learning, but also on biological and neurological processes that both facilitate and constrain intellectual development. This means that increasing one's intelligence is not just a matter of acquiring new information and skills; it is also a matter of neurological restructuring. So, to suggest that an entire generation has managed to become smarter is also to suggest that this generation has manifested accelerated brain development. Clearly, there are reasons to have reservations about the potential for significant accelerations of development, but there is some evidence that students today are smarter or more advanced in their development than same-aged students in previous decades. For example, there is the well-documented Flynn effect (1987, 1996; Storfer, 1990), which refers to a 3 point per decade increase in IQ scores over the last century. There is also one study that provides direct evidence to support accelerated development in today's youth. Flieller (1999) reports that children and adolescents of the 1990s were more advanced on Piagetian tasks than same-age children and adolescents interviewed in the 1960s and 1970s.

In our research, we employ an explicit model of intelligence informed by the cognitive developmental tradition of Piaget and his successors. In the cognitive developmental tradition, intelligence is neither a unitary nor a fixed state. Cognitive developmentalists define a spectrum of possible cognitive capabilities spanning a developmental hierarchy of increasing complexity and integration (Commons et al., 1998;

Fischer, 1980; Piaget, 1985). Within this framework, higher *developmental levels* are a central component in the expression of greater intelligence.

A more relativistic generation?

The "Millennials" are the first generation to grow up in the thick of contemporary multiculturalism—in a "freedom culture" where the singular and self-assured perspectives offered by comprehensive traditions have been refracted into a kaleidoscope of competing worldviews (Beck, 2001). The Baby Boomer generation remembers Jim Crow and the Civil Rights movement. Generation X remembers a world without the hyper-connectivity of an instant Global communications network. Neither of these generations faced the complexity, richness and diversity of intermeshed perspectives in which the Millennials are coming of age. The implications of this are exciting but unsettling (Beck, 2001; Mortimer & Larson, 2002).

In general, it is clear that growing up has become a longer and more contingent enterprise than it used to be (Arnett, 2000; Kerckhoff, 2002; Mortimer & Larson, 2002). Researchers have identified a unique phase of life known as *emerging adulthood*, which lasts from the ages of 18 to 25. This period of development during socialization is a new historical phenomenon. It is generally described as a prolonged period of role exploration and identity experimentation, facilitated by a relative independence from social and normative expectations (Arnett, 2000). Biographies become increasingly de-standardized and individualized during this phase. "Emerging adulthood is the only period in life in which nothing is normative demographically… The demographic diversity and unpredictability of emerging adulthood is a reflection of the experimental and exploratory quality of the period" (Arnett, 2000, page 471).

Because emerging adults are "not constrained by role requirements," they are open to engage with the full diversity of perspectives and lifestyles available in their culture. Youths report being aware of the lack of externally imposed direction and criteria by which to make choices. They are excited and encouraged, especially in college, to explore a variety of worldviews. This may sometimes leads to "the rejection of [simpler] beliefs without the construction of anything more compelling in their place" (Arnett, 2000). Relativism haunts emerging adults as they try to establish their place in life.

Adolescence and the transition into adulthood are increasingly affected by broader social and cultural patterns that foster differentiation, multiculturalism, diversity and individualization (Beck, 2001). Consequently, a radical form of relativism, in which all opinions are held to be equal, is increasingly becoming the default philosophy of American adolescents. While we primarily address the increasing prevalence of relativism in this paper, it is important to acknowledge the argument that a retreat to absolutism or fundamentalism is another way to deal with increasing pluralism and multiculturalism (Beck, 2001; Gardner, 2004).

Developmental maieutics

Dawson-Tunik's (2004a) approach to identifying sequences of conceptual development involves submitting interview data to multiple forms of qualitative analysis. First, interview texts are independently analyzed for their (1) developmental level and (2) conceptual content. Then, the results of these analyses are brought together and examined to identify trends in conceptual development. To conduct the developmental analysis, we evaluate the hierarchical structure of reasoning performances. To conduct the content analysis we attend to the specific meanings expressed in the same performances. Using this method, she and her colleagues have described developmental sequences for conceptions of energy, leadership, good education, epistemology, learning, morality, and the self, and for critical thinking, decision-making, and problem-solving (Dawson, 2004; Dawson & Gabrielian, 2003; Dawson & Stein, 2004; Dawson-Tunik, 2004a, 2004b; Dawson-Tunik & Stein, 2004a, 2004b; Dawson-Tunik & Stein, in review).

Hierarchical development

Developmental levels, also referred to here as *orders of hierarchical complexity,* are understood as a series of hierarchical integrations of knowledge structures. Many developmental theories employ the notion of hierarchical complexity. In the Piagetian model, for example, each successive hierarchical integration produces novel understandings by employing the operations of the previous order as conceptual elements in its new constructions. This notion is central to several other developmental theories as well, including those of Werner (1948), Case (1985), and Fischer (1980), and underlies a number of developmental scales, such as the levels and tiers of Fischer's (1980) skill theory and the complexity orders of Commons' General Stage Model (Commons *et al.*, 1998).

The Lectical™ Assessment System (LAS)

Several attempts have been made to develop a generalized developmental assessment system. Indeed, Piaget defined each of his developmental stages in generalized terms. Conservation, for example, is a general feature of concrete operations and can be observed on a wide range of tasks. Case (Case *et al.*, 1992), Fischer (Fischer & Bidell, 1998; Rose & Fischer, 1989), and their colleagues have employed generalized definitions to scale performances across domains, but have not disseminated generalized scoring systems. Based primarily on Commons' General Stage Scoring System (Commons *et al.*, 2000) and Fischer's skill theory

(1980), the LAS (Dawson-Tunik, 2004b), employed here, lays out explicit general criteria for determining the complexity level of performances in any domain of knowledge.

The thirteen skill levels described by Fischer (Fischer & Bidell, 1998) and the first 13 of Commons' 15 stages are defined similarly. We employ the level names from Fischer's skill theory to label our complexity levels. These are (0) reflexive actions, (1) reflexive mappings, (2) reflexive systems, (3) single sensorimotor actions, (4) sensorimotor mappings, (5) sensorimotor systems, (6) single representations, (7) representational mappings, (8) representational systems, (9) single abstractions, (10) abstract mappings, (11) abstract systems, and (12) single principles/axioms.

Scoring for complexity level

The scoring procedures employed with the LAS are partially derived from Commons' (Commons *et al.*, 1995) and Rose & Fischer's (1989) assessment systems. Like its predecessors, this scoring system is designed to make it possible to assess the hierarchical complexity of a performance through its level of differentiation and integration without reference to its *particular* conceptual content. Rather than making the claim that a person occupies a level because he or she has, for example, elaborated a particular conception of justice, the LAS permits us to identify performances at a particular complexity level and then to ask (empirically) what the range of justice conceptions are at that complexity level. Thus, it avoids much of the circularity[i] of many stage scoring systems (Brainerd, 1993), such as the Perry (1970) scheme and the Reflective Judgment Scoring System (King & Kitchener, 1994), which define stages in terms of domain-specific structures like social perspective-taking, or form of relativism.

It is possible to assess the complexity level of text performances because hierarchical complexity is reflected in two aspects of performance that can be abstracted from particular conceptual content. These are (a) hierarchical order of abstraction and (b) the logical organization of arguments. Hierarchical order of abstraction is observable in texts because new concepts are formed at each complexity level as the operations of the previous complexity level are "summarized" into single constructs. Halford (1999) has suggested that this summarizing or "chunking" makes advanced forms of thought possible by reducing the number of elements that must be simultaneously coordinated, thus freeing up thought processing space and making it possible to produce an argument or conceptualization at a higher complexity level.

At the complexity levels of single reflexive actions, single sensorimotor schemes, single representations, single abstractions, and single principles, the new concepts not only coordinate or modify constructions from the previous complexity level, but are qualitatively distinct conceptual forms: reflexes, schemes, representations, abstractions, and principles, respectively (Fischer, 1980; Fischer & Bidell, 1998). The appearance of each of these conceptual forms ushers in three repeating logical forms: single elements, mappings or relations, and systems.

Because these three logical forms are repeated several times throughout the course of development, it is only by pairing a logical form with a hierarchical order of abstraction that an analyst can make an accurate assessment of the complexity level of a performance. Consider these two structurally identical statements: "In a good education, you get to have recess so you can play with your friends," and "In a good education, you get to socialize so you can learn how to relate to other people." Both are mappings. The first sentence is a *representational* mapping because its conceptual elements are representations. The second sentence is an *abstract* mapping because its conceptual elements are abstractions. Without the distinction between representations and abstractions, it would be difficult to accurately score these texts. Other researchers have observed and described similar conceptual forms and repeating logical structures (Case, 1991; Fischer, 1980; Overton *et al.*, 1987; Piaget & Garcia, 1989).

Logical and conceptual structures are identical by definition. We make a distinction between the two types of structure for heuristic and pragmatic reasons. When scoring texts, hierarchical order of abstraction refers primarily to the *inferred* meaning of the structure of elements within a statement or argument based on the context. Logical structure refers to the *explicit* way in which these elements are coordinated in a given text. For a more complete account of the scoring system, see the LAS web site (Dawson-Tunik, 2004b).

Reliability and validity of the scoring system

We have undertaken several studies of the reliability and validity of the LAS and its predecessors (Dawson, 2002, 2003, 2004; Dawson & Gabrielian, 2003; Dawson *et al.*, 2003; Dawson-Tunik, 2004a). We have examined inter-analyst agreement rates, compared scores obtained with the LAS with scores obtained with more conventional scoring systems, and examined the functioning of the scale through statistical modeling. Inter-analyst agreement rates have been high, 80% to 97% within half of a complexity level (Dawson, 2004; Dawson & Gabrielian, 2003; Dawson-Tunik, 2004a)[ii]. Correspondences between other developmental scoring systems and the LAS are also high, consistently revealing agreement rates of 85% or greater within ½ of a complexity level (Dawson, 2002, 2004; Dawson et al., 2003). Employing Rasch scaling, which provides reliability estimates that are equivalent to

Cronbach's alpha, we have consistently calculated reliabilities over .95 (Dawson, 2002; Dawson et al., 2003; Dawson-Tunik, 2004a). Overall, our research shows that the LAS is a valid and reliable general measure of intellectual development from early childhood through adulthood.

In this article, we examine the development of conceptions of truth/reality with the goal of tracing the development of relativism across the lifespan. We then compare two sets of Kohlbergian moral judgment interviews to ask whether the incidence and forms of moral relativism changed during the second half of the last century.

Study 1

Method

Sample

The sample for the first study was composed of 108 5- to 56- year-olds[iii]. Age was distributed as shown in Table 2. The sample included children in a local after school program, teenagers in a local high school, and adults working in a government agency. It is best characterized as a convenience sample.

---------------------------insert table 2 about here---------------------------

Instrument

The interview instrument was one of two forms of the television dilemma (one for young children and the other for adolescents and adults) and a set of standard probe questions, as follows:

> Dilemma for children: Parents disagree about whether television is good or bad for children. Some parents say it is good for children to watch as much

TV as they want. Other parents say that all TV is bad for children. What do you think: Is TV good or bad for children? When adults disagree, how can you tell which adult knows best? Can you ever be sure which side is right?

Dilemma for adolescents and adults: 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.

Standard probes

1a. What do you think of these opinions? Have you formed an opinion on this issue? How did you decide what was right?

1b. How is it possible that parents/psychologists can disagree?

1c. What is the best way to decide about a problem like this one? Why?

1d. When you make a choice, can you be sure that you are right? Why or why not?

1e. How can you tell when you know the truth?

1f. Do you think there are things that everybody thinks are true? Why?

Interviews were tape recorded and transcribed, then divided into protocols (scoring units) by probe question. There were from 2 to 7 completed probes per interview. There were fewer successful probes from interviews with young children than with adolescents and adults.

Scoring

To assess the developmental level of the interviews for both studies, we employed the LAS. Table 1 provides short definitions of complexity levels 7 through 12 and shows correspondences between complexity orders, stages of reflective judgment, and epistemological positions.

The LAS is based on a three-layer model of conceptual structure. In this model—illustrated in Figure 1—the outer layer represents *conceptual content*, the middle layer represents *domain-level structure*, and the inner layer represents *core* structure.

___________insert Figure 1 about here___________

As reported above, the LAS targets core structures. These are *hierarchical order of abstraction* and *logical structure*. Most other scoring systems target domain-level structures such as sociomoral perspective or type of relativism. Many of these scoring systems also target conceptual content. It is much easier to score using a system based on domain structure and conceptual content than it is to score using a system focused on hierarchical order of abstraction and logical structure. The former primarily involves matching the arguments made by a respondent with exemplars in a scoring manual. The latter involves an examination of the deep structures implicated in the meanings conveyed in a given text.

Domain-based scoring manuals are generally based on the conceptualizations of a small sample of respondents and are extremely expensive and time consuming to produce. This limits their generality and availability. LAS analysts assign a complexity level score based on hierarchical order of abstraction and logical structure. To do this, they must understand how these manifest in a given performance. Scoring is an iterative process; the analyst alternately examines each layer of structure until he or she converges on an interpretation of the core structure of the performance. For example, an analyst was asked to score the following interview segment:

> [*Could you have a good life without having had a good education?*] Yeah, probably so, I would say. I wouldn't...it would be richer with education, but it wouldn't... [*Why do you think it would be richer with education?*] Well, you just, your mind would be open to a lot more things (0212).

The analyst's response illustrates how each layer of structure plays a role in the scoring process:

> Well, this isn't a very sophisticated notion of the role of education in the good life. Especially because, at first, I thought that he was saying that you'd be richer, money-wise (laughter), with an education. That would make "richer" a [representational] notion, but I see that it's actually at least abstract, because it's related to this idea of open-mindedness. It seems there are two variables [richer life, open mind] that are in a logical relation to one another…as in, "If you get a good education, your mind will be more open, and therefore you will have a richer life." This would make it at least [abstract mappings], but could it be higher than that? Well, *richer life* could be higher than [single abstractions], and so could *open mind*, so I'm looking for evidence that they are…but the perspective here is of the individual person and his life, without bringing in anyone else's perspective, or a social perspective, so you can't say, really. [Abstract mappings]; I'll stick with that.

In this example, the analyst appeals to all three levels of structure. The content level is referenced in her initial attempt to understand the argument, and again when she double checks her understanding at the end. The domain structure level is briefly included when she examines the social perspective of the respondent to see if there are grounds for considering the possibility that the statement is of a higher level than abstract mappings. The core structure is reflected in her analysis of the hierarchical order of abstraction and logical structure of the argument.

From this example, it is clear how *meaning* is central to the scoring process. Without a correct interpretation of the meaning of a statement, the analyst cannot even begin the process of scoring. In this case, knowing which sense of *richer* is intended by the respondent is essential to a correct interpretation of the hierarchical order of abstraction of the concept.

Each of the protocols in the data set for the first study was scored with the LAS, employing the 5 phase version of the scoring system. In this version, the analyst not only states the complexity level of a protocol, but one of 5 phases: transitional in, unelaborated, elaborated, highly elaborated, or transitional out. A mean score was then calculated for each respondent. The levels identified ranged from elaborated representational mappings to single principles. Mean scores were then rounded and assigned to one of 9 complexity phases as follows: elaborated representational mappings, unelaborated representational systems, elaborated representational systems, unelaborated single abstractions, elaborated single abstractions, unelaborated abstract mappings, elaborated abstract mappings, unelaborated abstract systems, elaborated abstract systems, and unelaborated single principles. Table 3 shows the distribution of these scores.

----------------------------insert Table 3 about here----------------------------

Concept coding

The scoring protocols employed with the LAS are general, which is why they be applied in any content domain. All the analyst considers is the logical structure and hierarchical order of abstraction of a given performance, "looking through" its particular conceptual content. This means that the conceptual content of texts can be submitted to an independent analysis. We conducted a detailed analysis of the propositional content of the interviews collected for this project, first employing a simple coding scheme. The scheme was developed by the first author on the basis of an examination of a subset of interviews and a review of themes identified in the literature. The coding categories for this scheme are shown in Table 4.

----------------------------insert Tables 4 & 5 about here----------------------------

Protocols were coded by a single coder, trained by the first author, into as many categories as were applicable. At frequent intervals throughout the coding process, the first author examined the coding results to determine coding consistency. The coder was occasionally asked to change coding categories following these assessments. After coding was complete, we employed information about the distribution of these codes (Table 4) and the original interviews to examine the relation between the conceptual content of the interviews and their complexity levels, focusing on questions about the nature of truth and reality.

Results

As shown in Table 5, we identified several ways of conceptualizing truth/reality, each of which appeared for the first time at a particular developmental level. Among the most interesting findings were that (1) claims that *the truth is uncertain*, *the truth can be found*, and *the truth is relative* were found at every complexity level; moreover, (2) these three codes coexisted within at least some individual performances at every complexity level, and

(3) claims about the certainty of truth in the physical world and truth in the social world appeared to develop along different trajectories.

Figure 2 shows the basic concepts that form the (initially) independent notions of truth in the objective world and truth in the social world. At the base of the figure are the concrete precursor insights observed at representational mappings and representational systems. These included assertions like (1) two people can have different beliefs; (2) what is right/true in one's own home might be different that what was right/true in another child's home; (3) some knowledge—like how many monkeys there are in the world—is not possible to obtain; and (4) people can be fooled about the truth by lies or fakes. At the single abstractions level these are integrated into more generalized conceptions of *fact* and *proof*, as applied to knowledge in the objective world, and *belief* and *opinion* as applied to knowledge in the social world. At the abstract mappings level, concepts like proof and factuality are further differentiated and integrated to form conceptions of information quality and accuracy. For example, facts and proofs can be evaluated for their accuracy, perhaps by including an assessment of the quality of an information source. In the social world, emerging conceptions at abstract mappings include notions of bias and perspectives that elaborate and integrate single abstractions notions of belief and opinion.

At the abstract systems order, in reasoning about the objective world, abstract mappings notions of information and accuracy are integrated into the notion that all information is more or less valid and requires evaluation. In reasoning about the social world, respondents integrate abstract mappings notions of bias and perspectives to construct the idea that all social knowledge is subject to cognitive or social limits that result in multiple perspectives and produce bias. At this level, it becomes increasingly difficult to distinguish between reasoning in the objective and social worlds, as many respondents employ evidence of cognitive or social limits to explain difficulties in determining truth in the objective world.

Finally, at single principles, reflections on the objective and social worlds are integrated through a notion of paradigms or models, which subsume notions of evidence, validity, and cognitive or social limits.

The roots of relativism are in the social world. Early responses to questions about truth in the objective world center on quality of information rather than doubt about a concrete reality. For example, a 5-year-old who asserted that there could be such a thing as fake cheese already knew that things are not always as they seem. Early responses to questions about truth in the social world, however, center on differences between what is true for you and what is true for me. Gradually, over the course of development, conceptions of social relativism are integrated into conceptions of truth in the objective world.

Virtually all performances were associated with at least one form of relativism (though to different degrees), suggesting that the notion that social knowledge is uncertain originates early in development. We identified 4 distinct forms of relativism, each of which appeared for the first time at a particular complexity level. The first form of relativism we encountered, which we call *nascent relativism*, was associated with representational mappings and representational systems performances. This form of relativism is associated with an early awareness that people can disagree about what is true, good, or right. The second form of relativism we encountered, *subjective relativism*, was associated with single abstractions performances and abstract mappings performances. Exponents of this form of relativism assert that there is no basis for evaluating truth claims because everyone has his or her own opinion. The third form of relativism we encountered, *contextual relativism*, was first associated with abstract systems performances (ages 18+). In this form of relativism, truth claims are viewed as difficult to evaluate, because people approach social or moral problems from different social and personal contexts. The fourth form of relativism we encountered, *paradigmatic relativism*, was first associated with single principles performances (ages 30+). In this form of relativism, truth, though ultimately unknowable, is viewed as something to be worked toward through successive approximations or models.

Discussion

The results indicate that relativism, rather than being symptomatic of an adolescent developmental crisis as suggested by previous researchers (Colby & Kohlberg, 1987a; Kitchener & King, 1990; Perry, 1970), is a gradually developing phenomenon. However, some respondents clearly exhibit more evidence of relativism than others. These findings raise at least one set of related questions, the first two of which we attempt to address in the next section of this article. First, to what extent is relativism a culturally mediated phenomenon? Second, are some individuals predisposed to taking a more relativistic stance than others, independent of developmental level? Finally, are the more radical forms of relativism associated with developmental transitions or do they represent relatively stable dispositions?

Study 2

Method

Sample

We searched a large database of over 1000 moral judgment interviews to identify adolescents between the ages of 13 and 18 who were interviewed in the 1950s (and early 1960s) and the 1990s. Because all of the earlier interviews were from Kohlberg's original moral judgment study (Colby & Kohlberg, 1987a, 1987b), which involved only males, we restricted the entire sample to males. We identified 72 interviews of adolescent males who were interviewed in the 1950s and 50 interviews of adolescent males—"Millennials"—who were interviewed by Berkowitz and his colleagues (Berkowitz *et al.*, 1994) in the 1990s. Age was distributed as shown in Table 6. Some of the interviews of the 18-year-olds in the sample from Kohlberg's original study were of the same boys who were interviewed at age 14 (4 years earlier). All of the interviews used in this project were responses to the Heinz dilemma, part of Form A of the *Moral Judgment Interview*:

> In Europe, a woman was near death from a special kind of cancer. There was one drug that the doctors thought might save her. It was a form of radium that a druggist in the same town had recently discovered. The drug was expensive to make, but the druggist was charging 10 times what the drug cost him to make. He paid $400 for the radium and was charging $4000 for a small dose of the drug. The sick woman's husband, Heinz, went to everyone he knew to borrow the money and tried every legal means, but he could only get together about $2000, which is half of what it cost. He told the druggist that his wife was dying, and asked him to sell it cheaper or let him pay later. But the druggist said, "No, I discovered the drug and I'm going to make money from it." So, having tried every legal means, Heinz gets desperate and considers

breaking into the man's store to steal the drug for his wife (Colby & Kohlberg, 1987b).

Interviews were tape-recorded and transcribed verbatim. Respondents were asked a number of standard probe questions, such as:

1. Should Heinz steal the drug? Why or why not?
2. Is it actually right or wrong for him to steal the drug? Why?
3. Does Heinz have a duty or obligation to steal the drug? Why?
4. If Heinz doesn't love his wife, should he steal the drug for her? Why?

In comparing samples from these two decades, we are aware of a number of threats to the integrity of the sampling procedure. In asking whether these samples, aside from being taken from different decades, are from similar populations, we come up against two major problems. First, the samples are different in their locations and demographics. All of the interviews from the 1950s were with boys enrolled in a private East Coast school (Colby *et al.*, 1983), whereas the interviews from the 1990s were with a sample of Midwestern working and middle class boys (Berkowitz et al., 1994). Despite these sampling problems, data of this kind are so rare that we decided it was worthwhile to conduct this investigation.

______________insert Table 6 about here______________

Scoring

Before scoring the responses to the Heinz dilemma, the interviews were divided into segments, or *protocols*, by probe question. There were from 4 to 14 protocols per interview, depending upon the probes employed by different interviewers. Each of these protocols was scored with the LAS and a mean score was calculated for each respondent. Inter-analyst reliability is reported in Dawson and Gabrielian (2003).

Concept coding

All of the interviews were coded for their conceptual content by the second author. Conceptual categories and the distribution of these categories by developmental level are shown in Table 7. There were statistically significant trends in the distribution of concept categories by developmental level for *unsure*, *speak for self*, and *culture/society*. The trend for *belief/opinion* approached statistical significance ($p<.09$). Unfortunately, due to the small cell values, these results must be interpreted with caution.

___________insert Table 7 about here___________

Results

Complexity levels

The mean complexity levels identified in this sample are typical of the same age groups in previous studies of developmental attainment (Armon, 1984; Dawson-Tunik, 2004a; Fischer & Bidell, 1998; Kitchener & King, 1990). Level 10 (abstract mappings) is the modal developmental level for most of this age-range.

There were no statistically significant differences between the cognitive developmental levels of adolescents from the two samples of moral judgment interviews. Table 8 shows the distribution of mean scores within the different age groups by decade.

___________insert Table 8 about here____________

These results suggest that the core reasoning structures of Millennials may be similar to those of mid-century adolescents. However, this does not mean that Millennials are identical to adolescents of the 1950s. We observed important differences in the content of their reasoning. In other words, the Millennials are thinking different things, even though (in this sample) they are not displaying unprecedented intellectual capabilities.

Relativism

Table 9 shows the distribution of conceptual categories by decade, and Table 10 offers a more detailed breakdown of content categories by decade and developmental level. Uncertainty, relativistic references to belief or opinion, and the notion that one can speak only for oneself were statistically much more likely to appear in the interviews conducted in the 1990s. In fact, respondents from the 1990s were more than 4 times more likely to express uncertainty, almost 4 times more likely to make relativistic references to belief or opinion, and 10 times more likely to express the notion that one can speak only for oneself. If these findings are conclusive—and additional research is required before we can feel confident in making this assertion—there has been a major shift in the moral reasoning of American youth.

_____________insert Tables 9 and 10 about here_____________

What does this shift mean in terms of the moral decisions made by the youth in these samples? A more detailed look at their conceptions reveals a number of important differences.

A closer look at subjective relativism

What we identified in the first study as *subjective relativism* consists of a cluster of notions, all of which increased in respondents from the 1990s: uncertainty, relativistic references to belief or opinion, and the notion that one can speak only for oneself. All three notions are associated with reasoning scored at level 10, though there are some precursors at level 9 and some of these notions persist at level 11 in a somewhat different form. By looking more carefully at the way these notions are employed in moral arguments at level 10, we can discern how subjective relativism affects the meta-ethical orientations of those who reason in this manner. We will see that uncertainty and the notion that one can speak only for one's self are symptoms of a general adherence to the relativistic position that personal beliefs, opinions and interests constitute moral norms. Furthermore, we will see that as reasoning becomes more complex, subjective relativism transforms into to *contextual relativism,* which construes the same basic meta-ethical orientations in more complex ways.

It is important to note that subjective relativism should be understood as an ideal type; it is not likely that any respondent would exhibit subjective relativism on all issues in all knowledge domains. Rather, the relativism we lay out here in abstract structural terms is more or less approximated by individual respondents, and varies according to context. So, while what is general across respondents is being emphasized here, one should not view this abstract homogeneity as an actuality. Each respondent in our sample manifested a unique version of subjective relativism.

The clearest way to get a sense of subjective relativism is to look at some examples. As a mode of moral reasoning, it is marked by an awareness of differences between people and what they believe to be morally "good" or "right." Several respondents referred to a personal sense of morals:

> [*Why should you do everything you can to save another life*?] Because I cannot just watch somebody die. [*Why not*?] Because you just cannot. You

> just, you know … Because, I guess it's just a matter of your own sense of morals (case 0347, year 1990).

Or

> [*What should Heinz do with respect to the law*?] He should decide through his own sense of morals and what he believes is right. So, he can make a decision, a conscientious decision to obey or break the law, depending on what he believes, and what's at stake (case 0576, year 1990).

Again

> [*Is it important for people to do everything they can to save another person's life*?] Well, I guess it's really your choice. It's just really whether or not you think you should. It depends on what you think is right. I think you would have to give a lot of thought to it. This isn't something that you think about. I personally just think people should (case 0507, year 1990).

Each respondent in these examples expresses the belief that moral questions are matters of personal choice and preference; this is the crux of subjective relativism. However, it appears in different ways and in more or less radical forms. Sometimes it appears as the idea that each person has a different set of moral standards: "Morality is something within yourself, that you set as your own law, on what you feel is right" (case 1168, year 1950). Other times it appears with a more radical flavor, in the idea that the *good* or *right* is entirely dependent upon personal perceptions and beliefs: "He was doing what he thought was right, and whatever he thinks is right, is right—for him" (case 0347, year 1990). Despite varying degrees of solipsism (the theory that the self is the only thing that has reality and can be verified), the common meta-ethical thread is an emphasis on individuality, uniqueness, and variability—morality as a choice or disposition—instead of an emphasis on shared, general, and impersonal obligations.

As evidenced in the third example above, this leads to an inability to feel confident in making generalizations about what others will or should do in moral matters. This is the notion that one can speak only for oneself, and evolves from the belief that moral norms are dependent upon personal beliefs and opinions. It is most evident in short glosses that some respondents attach to their statements:

> [*Why is it important to save another person's life*?] Again, it depends whether he thinks it's justifiable. I personally think it's justifiable if you can save a person's life. I would save the person's life. Why? Because I think it's the right thing to do. I cannot be more sure than that—I mean I can't speak for him. [*What would be so wrong about not saving a person's life*?] Knowing that you had the opportunity to save someone's life and you didn't. That's a wrongdoing, in my eyes. (case 0576, year 1990)

Other examples reveal the connection between a relativistic understanding of how morality is formed by personal opinions and the belief that one can only speak for oneself.

> [*Why should Heinz steal the drug*?] Because I think that's the right thing to do. [*Why do you think it's right*?] I don't know. For myself, it would be right. Because I would want it done for myself. But maybe for him it wouldn't. I don't know. I guess I can really only say what I would do. (case 0412, year 1990)

Uncertainty consistently accompanies these expressions of subjective relativism. While this may not be as substantial of a conception as relativistic references to belief or opinion and the notion that one can speak only for oneself, uncertainty is the outcome of relativistic reasoning that weighs most heavily on the emotional and action-orienting ramifications of such thinking. Uncertainty can be disorienting and paralyzing.

> If you don't obey the law, either you or somebody else could… could end up injured or even dead. [Okay, and why is it important that people not end up injured or dead?] Well … I don't know. [Okay, in obeying the law, how does this apply to what Heinz should do?] Well…. I am stuck here. (case 341, year 1990)

> [Okay, all right, well, is it important for people to do everything they can to save another person's life?] Is it important? Yes. [Why should we save other people's lives?] I don't know. Because. Because, because I said so. I don't know. (case 0222, year 1990)

These examples in particular demonstrate that important meta-ethical issues are mired in uncertainty. Although it is common, uncertainty is not felt while trying to figure out how to apply a moral norm to a specific situation. Instead, we see uncertainty in attempts to articulate and explain some of the most basic and fundamental moral intuitions; inarticulacy concerning the fundamentals of the moral *ought*. This kind of deep moral uncertainty and inarticulacy is a bedfellow of subjective relativism and seems to follow logically from its premises.

Another conceptualization that appeared in greater numbers in the reasoning of the Millennials was one in which culture, society, and upbringing were implicated in the nature of morality. This is not another facet of subjective relativism; rather, it marks the developmental transition from *subjective relativism* to *contextual relativism* (complexity level 10/11). As the reasoning of respondents becomes more abstract, complex, differentiated, and integrated, relativism begins to be articulated in terms of broader contextual determinates of moral choice and perspective. The transition from *subjective relativism* to *contextual relativism* involves observing that the opinions and beliefs that constitute an individual's personal moral sense are dependent upon culture, society, or upbringing.

> It's not his duty to steal the drug. It depends on whether he thinks he should or not. And that depends on his basic upbringing and the way his mind was shaped. (case 1146, year 1950)

The second sentence in the example expresses subjective relativism, and the third expresses contextual relativism. Again, from the same interview:

> But morally speaking, I can say I think I would have done it. He would have to make up his own mind, and he probably loved his wife very much and wouldn't want to lose her. Of course, it depends on his religion and culture. [*How do you mean*?] Well, I talked to some Jehovah's Witnesses and they are strict followers of the Bible. They don't believe in transfusions and things like that. In that case, if somebody was in need of a transfusion, if it were a loved one, they wouldn't allow it. And the one who was suffering wouldn't want to receive a transfusion. They believe … they must follow all His [God's] rules to the letter. I believe in freedom. If that's what they believe, who are we to say what is what? [*Are you saying that Jehovah's Witnesses are right*?] No, I am not saying they are right or they are wrong (case 1146, year 1950).

Here, subjective relativism is subsumed within contextual relativism. Contextual relativism means understanding the construction of moral norms as being relative to cultures and societies (or in this case, religion) instead of to an individual's beliefs and opinions. Here, belief systems determine the *good* and the *right*, and conflicting interpretations of morality must be hashed out cross-culturally. Differences in opinion are traced back to the broader, incommensurable worldviews from which they draw their substance.

Discussion

This study was designed to address three questions: (1) Are there cognitive developmental differences between the moral judgment performances of adolescents growing up in the 1950s and 1990s? (2) How is the phenomenon of moral relativism manifested in these interviews and how is it affected by cognitive development? (3) Did moral relativism increase from the 1950s to the 1990s?

The results of our developmental analysis of the interviews forces us to answer *no*—tentatively, at least—to the first of these questions. The Millennials in our sample were no more developmentally advanced than the adolescents of the 1950s and 1960s.

To the second question, we have a more complex answer. We identified two forms of relativism: *subjective* and *contextual.* Subjective relativism was identified primarily at complexity level 10, whereas contextual relativism was identified primarily at complexity transitional level 10/11 and level 11. Subjective relativism expresses the belief that everyone has an opinion, and every opinion is as good as any other; It is nicely summed up with the indifferent catch-phrase, "It's all good." Contextual relativism is a more mature form of relativism in that it encompasses the broader perspective of the society or culture. Contextual relativists see values as they relate to social systems, religions, organizations, and so on.

What is good is what they, as a group or culture, have decided is good. They understand that there are differences across groups and cultures, but they know where they stand within their own cultural milieu and are compelled to act according to those particular values.

Finally, to the third question, we must answer *yes*; Moral relativism does characterize the epistemologies of the Millennials in our sample, and because this increasing relativism is unaccompanied by developmental advance, it most commonly takes the form of *subjective relativism*.

Conclusions

The first study builds upon the work of Perry (1970) and King and Kitchener (1994) in two ways. First, it extends the study of the development of relativism into childhood, where we discover that the roots of relativism are formed as early as age 5. Second, our methodology, which allows us to conduct independent analyses of structure and particular conceptual content, made it possible to describe a number of alternative conceptions for each developmental level, and allowed us to distinguish between two relatively independent developmental strands that contribute to more developed relativistic thought. In the realm of the objective world, doubts about truth were expressed in terms of quality of information, whereas in the social world, they were expressed in terms of personal differences. Interestingly, the second strand is more closely identified with what philosophers call “moral relativism”, whereas the first is more closely identified with what philosophers call “cognitive relativism”. These two strands appeared to develop more or less independently until fairly late in development, when the concepts originally identified in reasoning about the social realm were often integrated with the concepts originally identified in reasoning about the objective world.

We also identified 4 types of relativism—nascent, subjective, contextual, and paradigmatic—two of which we identified and elaborated in the second study, in which we examined differences in relativistic thought in samples of moral judgment interviews collected in the 1950s and 1990s. In the second study, we observed four to tenfold increases in indicators of subjective relativism, a particularly problematic form of relativism, which compels us to ask, "What should be done?"

Millennials are not subjective relativists by chance; they have acquired this perspective as a means for coping with the diversity, multiculturalism and complexity of their culture (Beck, 2001). Therefore, subjective relativism cannot simply be replaced with a less relativistic stance. Nor would such a simple exchange be desired, for subjective relativism is, in many ways, a hard won achievement both ontogenetically and phylogenetically (Habermas, 1984, 1987).

Historically, there have been few societies able to honor the dream of a "democracy without enemies," in which a plurality of cultures and ways of life could be valued. Such a goal is worth the confusion encountered during the struggle to achieve it. The Millennials may be the first generation truly searching for an adequate way to deal with the cognitive demands of this situation. No previous generation has been so openly confronted with the multitude of voices liberated by the idea that "all humans are created equal" and that there should be "liberty and justice for all" (Beck, 2001). Seen in this light, the confusion of subjective relativism is not so much a mishap as a growing pain. To deal with subjective relativism requires confrontations with diversity; It entails developing more adequate forms of relativism and better ways of dealing with the complexities of pluralism (Habermas, 1990).

We think the tensions and inadequacies of subjective relativism can only be relieved with the development of more complex thinking, specifically a move into contextual relativism (Kegan, 1994). While subjective relativism emphasizes how individuals self-prescribe norms in light of their personal opinions and beliefs, contextual relativism views personal opinions and beliefs as being constructed from *shared* cultural norms and prescriptions. This difference allows contextual relativists to accept the norms shared by a group or culture as relatively valid, and thus embrace interpersonal obligations. Although contextual relativists lack the means to resolve cross-cultural moral disagreements (a task for *paradigmatic relativism* at complexity level 12), they can understand the inner-cultural dynamics that constitute the reciprocal patterns of obligation and the overlapping consensuses that validate the moral norms shared within communities. This is more advanced than the idea that norms are self-prescribed, which leads subjective relativists into conflicts with any interpersonal system of norms; "It's *all* good" becomes the equivalent of "nobody can tell *me* what to do" (Taylor, 1995).

It is by promoting cognitive development that subjective relativism can be transformed into a more constructive way of dealing with pluralism—a contextual relativism capable of grasping in more complex terms how moral norms are constructed within systems of belief (Kegan, 1994; Taylor, 1995).

Caveats and directions for future research

As noted in the methods sections, the samples employed here are convenience samples. Respondents in the second sample were not matched for any demographic variables beyond being representative of the wide-ranging designation of American working and middle class. Moreover, the sample included no females. We hesitate, therefore, to form any absolute conclusions. We are particularly hesitant to make too much of the finding that there was no change in developmental level of performance for same-age respondents between the two time periods. Although there are reasons to hypothesize that epistemological development would not necessarily speed up as a consequence of the complexification of children's experience over the last 50 years, further research must be conducted, with better controls for demographics such as SES, location, and type of educational institution, before any generalization is warranted.

The same is true for the observation of a 4–10 times increase in subjective relativism from the 1950s to the 1990s. While this finding supports the hypothesis that the increasing emphasis on pluralism during the last 60 years is associated with an increase in moral relativism, we cannot entirely rule out the possibility that this finding is related to differences in the demographics of the two samples rather than, or in addition to, historical trends.

We did not explore expressions of fundamentalism in our sample. Future research, sampling a wide range of demographic groups, may provide similar evidence of change in the rate of fundamentalism.

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[i] When stages are defined in terms of particular conceptual content, it becomes possible to argue that (1) an individual is functioning at a given developmental level because he or she is

capable of producing a particular conception, *and* that (2) an individual is capable of producing a particular conception because he or she is functioning at a particular developmental level.

[ii] As of January 2004, certified LAS analysts must maintain an agreement rate of 85% within 1/3 of a complexity level with a Certified Master Analyst (Dawson-Tunik, 2004b).

[iii] Age, gender, and education information were not available for the group of 35 adult respondents interviewed for this project.

Table 1: Perry positions, stages of reflective judgment, and Lectical™ levels

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
No clear correspondence		Level 7	2nd order representations These coordinate or modify representational sets (the concepts constructed at the single representations level). The very popular representational mappings level concept of having favorites, for example, can be employed in the Television dilemma. "Cartoons	Mappings It coordinates one aspect of two or more representations—as in, "If you watch T.V when you mom says you can't she will get mad at you." in which not doing what your mother says is coordinated with her anticipated reaction.

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
			is my favorite to watch, and the Discovery Channel is my next favorite" Concepts like *being smart, changing one's mind*, and *not being allowed* also become common at this level. "I'm not allowed to watch T.V because it will make me dumb."	
No clear correspondence		Level 8	3rd order representations These coordinate elements of	Multivariate It coordinates multiple aspects of

Perry position (Perry, 1970)	Reflective judgment stage (King & Kitchener, 1994)	Lectical™ level	Hierarchical order of abstraction of Lectical™ level	Logical structure of Lectical™ level
			representational systems. For example, the concept of truth can be used to describe a system of observations about television "It's true, you know, that T.V. is not good for you, because everybody thinks T.V is bad for your brain, so it must be true. But I still watch, when I'm allowed because it's fun." Concepts like *being unsure,*	two or more representations—as in, "My mom says watching T.V. is bad for me, but my dad says that it is okay sometimes, so I don't know which is true. I hope my dad, because I like T.V." in which two conflicting parental truth clams are coordinated by an admittance of uncertainty, and by the statement of personal desire.

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
			to believe, and *being untrue* are also infrequently observed before this level.	
Position 2 Diversity of opinion is recognized, but attributed to the confusion of poorly qualified authorities.		Level 9 Single abstractions	1st order abstractions These coordinate 3rd order representations, which are equivalent to representational systems (the constructions of the previous level). For example, the generalization that everyone has	Definitional The most complex logical structure of this complexity level often identifies one aspect of a single abstraction, as in "What is true is what you believe," in which belief is a condition for truth.

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
			his or her own *beliefs*, coordinates multiple concrete observations of differences in opinion.	
Position 3 Diversity and uncertainty are accepted, but only because the "answer" has not yet been found.	Stage 3 Knowledge is either certain or temporarily uncertain. When knowledge is uncertain, only	Level 10 Abstract mappings	2nd order abstractions These coordinate or modify abstractions. For example, the level 10 concept of personal truth indicates that the individual differentiates between at least two categories of truth as a concept	Linear The most complex logical structure of this level coordinates one aspect of two or more abstractions, as in "Because we are all raised differently, each person has his own personal truths, based on

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
	personal beliefs can be known.		abstracted from concrete instances. Concepts like *universal truth*, *scientific truth*, and *belief vs. truth* are also not constructed before this level.	upbringing." Here, upbringing determines the kinds of truths we hold in adulthood.
Position 4 Everyone is entitled to her own opinion, but right and wrong still prevail in the realm of authority (or religion).	Stage 4 Knowledge is uncertain and all knowledge claims are opinions.			

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
Position 5 All (most) knowledge is viewed as contextual, though there are gradations of truth and a few right/wrong exceptions.	Stage 5 Knowledge is contextual and affected by perspective. Evidence is interpreted.	Level 11 Abstract systems	3rd order abstractions These coordinate elements of abstract systems. For example, the concept of *point of reference* can be employed at this level to differentiate between different methods of determining truth. Concepts like *gradations of truth*, the *pursuit of truth as an ongoing process*, and *selecting the*	Multivariate The most complex logical structure of this level coordinates multiple aspects of two or more abstractions. “Because some methods of determining truth, like the scientific method, produce more consistent results than others, in some cases where there is no absolute truth there are better and worse answers.” Here
Positions 6-7	Stage 6			

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
The student comes to understand that it is necessary for him to commit to a position within a relativistic world (6). This commitment is made (7).	Knowledge is constructed on the basis of evidence from multiple sources.		*appropriate method for determining truth* are also not constructed before this level.	the notion that there are better and worse methods for determining truth leads to the conclusion that even though knowledge is uncertain, some answers are better than others.
Positions 8+	Stage 7	Level 12	First order axioms	Definitional

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
The implications of commitment are explored as are notions of responsibility.	Knowledge is continuously modified in accord with new evidence.	Single principles	At this level, the new concepts are referred to as first order principles. These coordinate abstract systems. Concepts like *web of existing knowledge*, *interrelating truths to extract a single truth*, and *coordinating principle* are not constructed before this level.	The most complex logical structure of this level identifies one aspect of a principle or axiom coordinating systems, as in “Knowledge, viewed from a variety of perspectives can inform the structuring of truth, which is in eternal state of transformation.” Here, the respondent defines a principle for structuring truth that involves the

Perry position (Perry, 1970)	**Reflective judgment stage (King & Kitchener, 1994)**	**Lectical™ level**	**Hierarchical order of abstraction of Lectical™ level**	**Logical structure of Lectical™ level**
				coordination of different systems of knowledge.

Table 2: Age distribution of sample for study 1

Age	Frequency	Percent
5	2	1.9
6	4	3.7
7	7	6.5
8	5	4.6
9	3	2.8
10	8	7.4
11	2	1.9
14	13	12.0
15	21	19.4
16	4	3.7
17	3	2.8
18	1	.9
Adult	35	32.4

108	100.0

Table 3: Distribution of LAS phases

Phase	Frequency	Percent
Elaborated representational mappings	4	03.7
Unelaborated representational systems	4	03.7
Elaborated representational systems	12	11.1
Unelaborated single abstractions	12	11.1
Elaborated single abstractions	17	15.7
Unelaborated abstract mappings	12	11.1
Elaborated abstract mappings	24	22.2
Unelaborated abstract systems	12	11.1
Elaborated abstract systems	9	08.3
Unelaborated single principles	2	01.8
Total	108	100.0

Table 4: Concept codes and their distribution by complexity level

	Complexity level					
Code	**RM**	**RS**	**SA**	**AM**	**AS**	**SP**
The truth is uncertain	X	X	X	X	X	X
The truth can be found	X	X	X	X	X	X
The truth is relative	X	X	X	X	X	X
Believing	.	X	X	X	X	X
Fact	.		X	X	X	X
Proof	.	.	X	X	X	X
Opinion	.	.	X	X	X	.
Perspectives	.	.	X	X	X	X
Information source	.	.	.	X	X	.
Learning more	.	.	.	X	X	X

Bias	.	.	.	X	X	.
Considering values	.	.	.	X	.	.
Considering consequences	.	.	.	X	X	X
Accuracy of information	.	.	.	X	X	.
Evidence	.	.	.	X	X	X
Validity					X	X
Reliability of information	.	.		.	X	X
Cognitive/human/social limits on knowing	.	.	.	.	X	X
Paradigms	.	.	.	.	.	X

Table 5: Epistemological conceptions associated with complexity levels 7 – 12

Complexity level	**Conceptions of truth/reality**	**Example: Truth is certain/uncertain**	**Example: Truth is relative**
Level 7 Represen-tational mappings	At this level, truth/reality is conceptualized in two ways. 1. Conceptions of truth express the idea that objects that are simply present—objects and events (things) in their taken-for-granted-ness. These conceptions are found in relation to other (opposite) conceptions that express the idea that things are not always as they seem. These are the very first precursors to the conceptions of *truth* and *facts*. They express concrete assurances of the truth of	*[Now, here is another question. Do you think there are things that everybody thinks are true?] Yes. Cheese is real. [Cheese is real? Cheese is real. Yes. What do you mean, what do you mean by cheese is real?] It is real. [It is real? What do you mean by real?] It is real cheese. Is not fake. Cheese is not fake. [Cheese is not fake. What is fake? Well, can you tell me something that is fake?] Fake*	*[Do you think there are things that everybody thinks are true?] Probably no. [Why not?] Because most people have different thinkings. [Yes? How come?] like if, let us see, my mom and Lily's mom. My mom wanted to get a husky, a puppy which was a husky, and Lily's mom didn't. [Why do you think they make different decisions?] Because some people think this is better*

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	things as they are given to the senses and conceptions that some things fool you or are fakes. 2. Truth is qualified by expressions that reveal an awareness of disagreements. Here descriptions of particular disagreements, signify preconceptions of *beliefs* and *opinions*.	*cheese. [Fake cheese. All right. So everybody thinks that cheese is real, yes. So, why does everyone think that cheese is real?] Because it is cheese. [Because it is cheese. But, you said there is fake cheese. How can we be sure whether it is real or fake?] Fake cheese is plastic (30002).*	*and some people think that is better (30048).*
Level 8 Representational systems	At this level, truth/reality is conceptualized in two ways. 1. Conceptions of truth are expressed as general and varied observations and	[*And do you think there are things that everybody could agree is true?] Yes. [Like what kinds of things?] Like this school was*	[*Do you think there are things that everybody thinks are true?] Yes and no. [What do you mean?] Well, like, I will use Santa for one*

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	descriptions of things that are understood to be simply true. There is an emerging understanding that certain types of things tend to be true, while other things should be categorized as untrue, or uncertain. There is also an emerging tendency to attempt to explain why one has the idea that something is true or not. There are very clear precursors to the concepts of *fact* and *truth* that begin to push through the given-ness of objects and events in order to seek out reasons (or the lack of them), for thinking something is true, e.g.	*made of bricks. [You think people could agree on that?] Yes. [Yes?] And, like, agree on how it spells words and stuff or how to play a game, drive a car. [So what are some of the things that people would have a hard time agreeing about.] How to climb a tree. [Oh yes?] Because there is lots of different ways. How do draw, how to draw a picture because there are lots of different ways that you can draw a picture (30008).*	*impression. I do not, some people think Santa is real and some people do not. So, a lot of people think it is bad to lie, some people do not. So, I do not know. [Is there anything that everybody thinks is true?] I do not think so. [You do not think so? Why not?] But if it is in a book maybe and maybe not. I think it is true and it could be not. Yes and no. [Why do you think that it?] I do not know (3051).*

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	proof. There is also evidence of more careful differentiations between things that are true and things that aren't. 2. Conceptions of truth are qualified by general observation that disagreements can *mean* something. That is, disagreements between people are understood as common and as a kind of proof that not every body agrees with each other. Truth, the right thing or decision, is then taken to be something that people will argue about. There is also an emerging ability to conceive of different		

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	views as such, i.e., different people have different ideas about same 'thing'.		
Level 9 Single abstractions	At this level, truth/reality is conceptualized in two ways. 1. Truth is conceptualized in terms of abstract notions of fact (non-facts) and proof (or lack thereof). These are general concepts about differences between types of things that summarize a variety of insights into the given-ness of objects and events. At this level, *facts*, which are things that can be *proven*, are often the only things *considered to be true.*	*[Do you think that there are any things out there that would be absolute truth, true for everybody?] I am sure it is all opinion. [You are sure it is all opinion?] Well, some…yes sure there are some facts out there, but like most… [So what would you say is a fact, can you give me an example?] Well, WW2 ended in nineteen forty-one or something*	*[Do you think that there are any absolute truths, truths that are true for everybody, all the time?] No. [How come?] I believe that everyone has their different opinions, and what they think is what they want to think, and other people think what they want to think…like that (10364).*

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	2. "Everyone has their own opinion," appears as a common conception at this level. The main insight is that people have different opinions, which means they will not agree on things, and this means there isn't really a truth.	*like that (10368).*	
Level 10 Abstract mappings	At this level, truth/ reality is conceptualized in two ways: 1. Truth/ reality is conceived of 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	*[How do you arrive at the truth?] Probably through experience, time, valid sources… [Do you think there are any absolute truths?] Absolute truths? Yes, I guess some things are absolute truths. Your age is an absolute*	*[Do you think that there are any absolute truths?] No. [Why not?] Truths are what you believe. It's all in your belief. Is there a true God? Everybody has an opinion. Everybody has an opinion on…the scriptures. There's no*

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	theories change, often what is true/ real is unclear.) 2. Truth/ reality is conceived of 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 true/ real is unclear.)	*truth. Your weight is an absolute truth. [Why do you think these are absolute truths?] Because they are things that can be proven. There are multiple ways of scientifically proving them (20216).*	*truth there; you can only read them and then formulate your own beliefs (20219).* *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).*
Level 11 Abstract	At this level, truth/ reality is conceptualized in several ways: 1. Truth/ reality is conceived of as the sum	*When I think of absolute truth, I think, if you go through a process many times it will always come out*	*Your inner thoughts … your morality, your ethics, things that factor into a person's decision-*

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
systems	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 considered 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.	*the same way. It's absolute. It's like an engineering process. If you put the pencil there it will fall in that direction and that's the way it will fall, and it's an absolute truth that it will happen every time no matter what. And yet if you're talking from the perspective [of] human nature … there's a reasoning process … and your reasoning might be different than mine. Then, I can't say there's always an absolute truth (20209).*	*making—I think all of that is relative, meaning that depending on [your experiences] and how you've educated yourself … two different people could have completely different senses of what truth is because it's relative (20210).* *…[in] 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*

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	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		*[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).*

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	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 to be the case.		
Level 12 Single principles	At this level, truth/ reality is conceived of 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	*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 think that all knowledge is open to interpretation, and it's open to revalidation, and it's open to*	

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	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	*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).* *A lot of times we [think] we have found an absolute truth. Then 10, 15, 20 years later [we realize] that we don't have total understanding. So, what appears to have been an absolute truth was in fact just a model that fit our current understanding. The reason why it wasn't absolute is that we didn't have all the information we needed. So, I won't say that absolute truths don't exist. [And why not?] Because I think that eventually we will find that there is a fundamental basis for everything. The question is, have we reached that fundamental understanding, or have we just reached some interim understanding based upon our current knowledge? More often it's the latter rather than a set of*	

Complexity level	Conceptions of truth/reality	Example: Truth is certain/uncertain	Example: Truth is relative
	requiring different procedures of justification in different domains.	*absolutes (20056).*	

Table 6: Age distribution by decade of interview

	Decade	
Age	**50s**	**90s**
13	12	7
14	17	10
16	14	10
17	17	6
18	12	17
Total	72	50

Table 7: Distribution of content categories by complexity level

Category	**Definition**	**N(%) at level 9**	**N(%) at level 10**	**N(%) at level 11**	**Pearson chi-square**
Unsure	The respondent expresses uncertainty about the proposed solution.	4 (36.4%)	12 (12.4%)	0	7.38*
Relativism: belief/ opinion	Norms are relative to individual beliefs/ opinions.	1 (9.1%)	16 (16.5%)	5 (35.7%)	3.71
Speak for self	The respondent offers a solution, but claims he or she is capable only of speaking for his or her self, and/or withdraws any universal or prescriptive status from the solution.	1 (9.1%)	3 (3.1%)	4 (28.6%)	13.08*
Relativism: perspectives	Norms are relative to the different perspectives/ views of those involved.	0	8 (8.2%)	2 (14.3%)	1.67

Relativism: culture/ society	Norms are relative to cultural or societal decisions/ processes/ constructions.	0	2 (2.1%)	2 (14.3%)	6.17*

*Statistically significant at $p<.05$ level—to be interpreted with caution due to low cell values.

Table 8: Age distribution by decade of interview with mean scores for age groups

	Decade			
Age	**50s**		**90s**	
	n	**mean**	**n**	**mean**
13	12	9.5	7	9.4
14	17	9.8	10	9.9
16	14	9.9	10	9.9
17	17	10.2	6	9.8
18	12	10.3	17	10.1
Total	72		50	

Table 9: Distribution of content categories by decade of study

Category	1050s	1090s	Pearson chi-square
Unsure	4 (5.6%)	12 (24.0%)	8.81*
Relativism: belief/opinion	6 (8.3%)	16 (32.0%)	11.18*
Speak for self	1 (1.4%)	7 (14.0%)	7.66*
Relativism: perspectives	6 (8.3%)	4 (8.0%)	.00
Relativism: culture/society	2 (2.8%)	2 (4.0%)	.14

*Statistically significant at $p<.05$ level—to be interpreted with caution due where cell values are <5.

Table 10: Distribution of content categories by developmental level and decade of study

Category	**1050s N(%) at level 9**	**1090s N(%) at level 9**	**1950s N(%) at level 10**	**1990s N(%) at level 10**	**1950s N(%) at level 11**	**1990s N(%) at level 11**
Unsure	1 (20.0%)	3 (50.0%)	3 (5.2%)	9 (23.1%)	0	0
Relativism: belief/opinion	0	1 (16.7%)	4 (6.9%)	12 (30.8%)	2 (22.2%)	3 (60.0%)
Speak for self	0	1 (16.7%)	0	3 (7.7%)	1 (11.1%)	3 (60.0%)
Relativism: perspectives	0	0	4 (6.9%)	4 (10.3%)	2 (22.2%)	0
Relativism: culture/society	0	0	0	2 (5.1%)	2 (22.2%)	0

n	5	6	58	39	9	5

Figure 1: Layers of conceptual structure

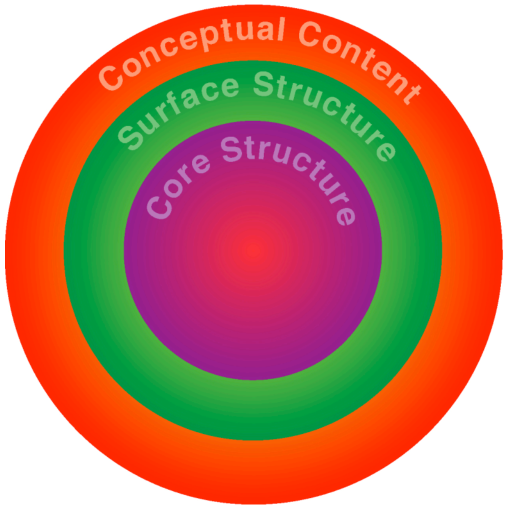
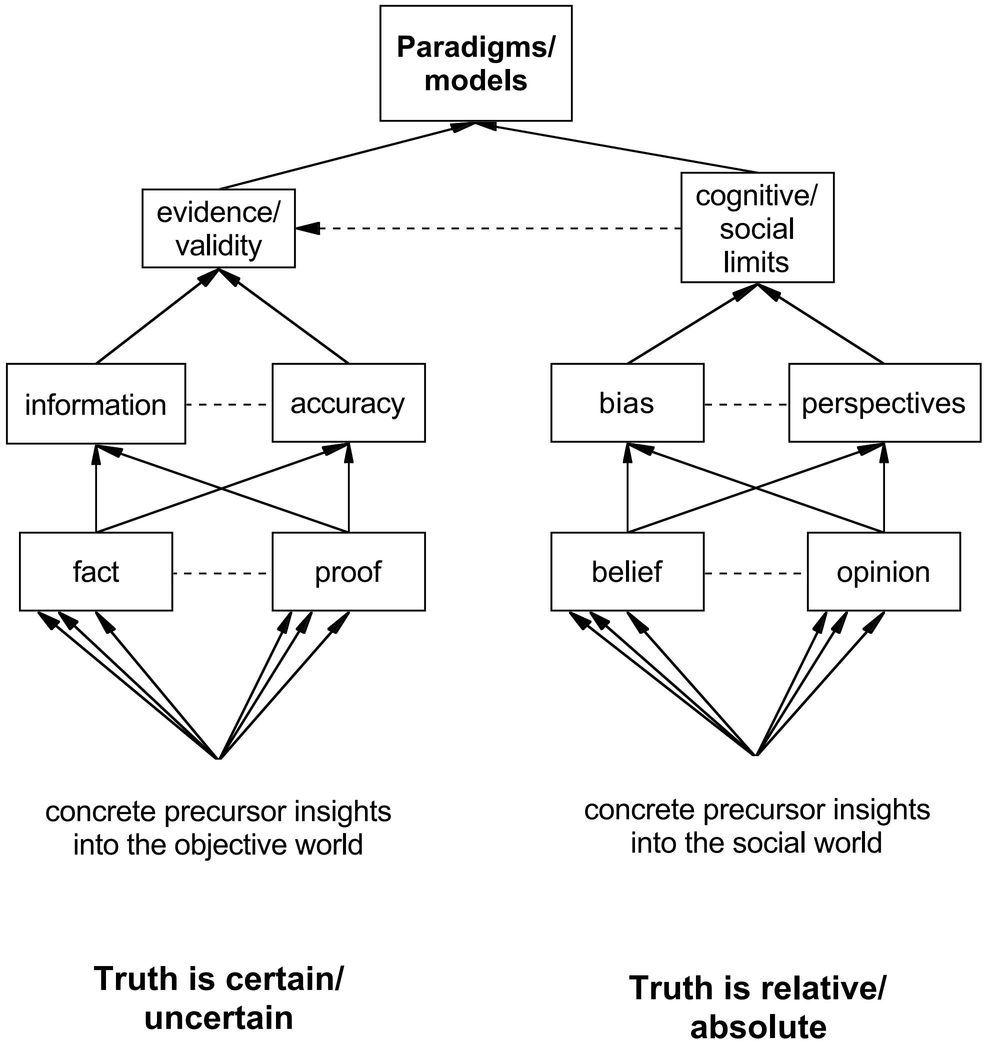


Figure 2: The development of relativism and notions of certainty and uncertainty



Appedix B: Collaboration for Excellence in Science Education Research Paper

Dawson-Tunik, Theo L. & Stein, Zachary (in review). "It has bounciness inside!" Developing conceptions of energy.

It Has Bounciness Inside! Developing Conceptions of Energy

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Abstract

We employed a research method called *developmental maieutics* to investigate the development of conceptions of energy in children and adolescents aged 5–16. All respondents participated in semi-structured clinical interviews designed to probe their reasoning about energy conservation. After transcription, the interviews were analyzed twice: They were scored with a general developmental assessment system, the Lectical Assessment System (Dawson-Tunik, 2004b), and submitted to a detailed analysis of their conceptual content. The combined results were used to construct an account of the development of energy conceptions in which conceptions classified as misconceptions by other researchers were found to be precursors of developmentally later conceptions.

Key words: developmental stages, hierarchical complexity, conceptual development, science concepts, physics, curriculum development

It Has Bounciness Inside! Developing Conceptions of Energy

An understanding of how scientific concepts are learned should be at the center of the emerging cooperative efforts between cognitive scientists and educators. There are few other areas of study that are better exemplars of what Carey (Carey, 1986) describes as the paradox of conceptual change; that to understand a particular conception, one must relate it to existing schemata for understanding the world, but the goal of science education is to instill new schemata that may be very different from existing schemata. How then is the student to understand texts and lessons aimed at presenting this new information?

An awareness of just how serious Carey's paradox is for science education has motivated attempts to probe the initial schemata children bring into the classroom in the hope of building bridges between "mis/preconceptions" and "accepted conceptions" or "novice" and "expert" knowledge states (Bowden *et al.*, 1992; Chi & Slotta, 1993; Clerk & Rutherford, 2000; di Sessa, 1996; Eryilmaz, 2002; Halloun & Hestenes, 1985; Hestenes *et al.*, 1992; Marton, 1986; Prosser & Millar, 1989; Slotta *et al.*, 1995; Stephanou, 1999). An understanding of the concept of energy is central to a number of scientific disciplines—including biology, physics, and chemistry—and therefore these conceptions have been the particular focus of numerous investigations (Duit, 1983; Goldring & Osborne, 1994; Kruger, 1990; Maloney, 1985; Shymansky *et al.*, 1997; Solomon, 1983; Stylianidou, 1997; Talisayon, 1988; Trumper, 1993; Watts, 1980; Welch, 1984).

We will first examine the theoretical perspectives and complementary research methodologies that have formed our current knowledge about the development of scientific conceptions. After outlining what is currently understood about the development of energy conceptions, we will explore the relation between these conceptions of energy and cognitive development by employing the methods of *developmental maieutics.*

Approaches to the Study of Physics Conceptions

Several research traditions address the paradox of conceptual change in science. All of these approaches incorporate a serious consideration of the nature of the state of initial knowledge in students. Many are guided by the belief that understanding the nature of students' "naïve," "intuitive," or "folk" theories will facilitate more effective pedagogical techniques that will better prepare the way for fundamental conceptual change. A universal observation in this literature is that the conceptions that children, adolescents, and adults bring to the classroom are slow to change, even when teachers employ the most effective available teaching methods.

Almost all research into the development of scientific conceptions has been informed by a constructivist perspective. Broadly stated, constructivism advances the notion that students construct knowledge gradually by incorporating new experiences into existing knowledge structures. One group of researchers has focused on elaborating the deep structures of these initial knowledge states (Amsel *et al.*, 1996), attempting to clarify the architecture of intuitive, everyday theories, mental models, or knowledge systems. Piagetian and neo-Piagetian approaches focus on the relation between general developmental processes and cognitive operations in science reasoning (Amsel et al., 1996; Case, 1991; Levin, 1977; Piaget, 1954). Other approaches focus more specifically on the epistemological conditions for the possibility of intuitive science concepts (di Sessa, 1996) or the ontological presuppositions behind misconceptions (Chi & Slotta, 1993; Slotta et al., 1995). This latter group of researchers seeks to explain the "resistance" of initial conceptions to educational efforts by revealing their internal coherence, experiential basis, and relative complexity.

Most researchers who have examined the development of energy conceptions take a phenomenological approach. One type of research focuses primarily on investigating what are often referred to as misconceptions, usually conceived of as incorrect conceptions that are resistant to change. A variety of qualitative methods have been employed to identify misconceptions (Duit, 1983; Goldring & Osborne, 1994; Kruger, 1990; Maloney, 1985; Shymansky et al., 1997; Solomon, 1983; Stylianidou, 1997; Talisayon, 1988; Watts, 1980; Welch, 1984) and to explore methods for replacing misconceptions with scientific concepts. In most research of this kind, conceptual development is thought of as a constructive process in which incorrect conceptions are replaced with correct conceptions.

Other researchers think of students' existing conceptions as the foundation for increasingly developed and adequate conceptions. Here, the effort is less directed at identifying and replacing misconceptions and more toward identifying the precursors of more developed conceptions. Among those with this orientation are researchers who have been guided by a Piagetian or neo-Piagetian perspective (Levin, 1977; Siegler & Atlas, 1976; Trumper, 1993). Researchers in this group either question how scientific concepts develop over time (Levin, 1977; Selman, 1979; Siegler & Atlas, 1976) or how conceptual development in science is related to cognitive development (de Lisi & Staudt, 1980; Howe et al., 1990; Trumper, 1993).

Another important approach to describing scientific conceptions has emerged from a research tradition known as *phenomenography* (Marton, 1981, 1986). Phenomenographers employ a formalized qualitative research methodology to analyze and describe the kinds of initial conceptions found in intuitive, everyday science reasoning (Bowden et al., 1992; Prosser & Millar, 1989). The products of this approach are suggestive and rich taxonomies of scientific conceptions. The resulting *concept inventory* is sometimes differentiated and organized according to criteria revealed in the relations between types of conceptions, such as their relative explanatory capacity and complexity. From this, researchers can construct a hierarchy of increasingly adequate conceptions in which learning is conceived as movement up a developmental hierarchy (Bowden et al., 1992). Unfortunately, research related specifically to the development of the energy concept is sparse in both the Piagetian and phenomenographic literatures.

Energy Conceptions

Research on energy conceptions has focused primarily on identifying and categorizing misconceptions (preconceptions, naïve conceptions, intuitive conceptions), comparing the conceptions of different age groups, comparing pre- and post-instruction concepts, or comparing the conceptions of relative novices with those who have had more exposure to scientific energy conceptions. Though the conceptions of both children and adults have been studied, our research focuses on children and adolescents. Therefore, we have not reviewed the research concerning energy conceptions in adults. Neither do we engage many of the questions that concern the investigators whose work is reviewed here. Because our interest is in how energy concepts develop over time, we confined our review to the most relevant aspects of the existing literature. The major question we address to this literature is, therefore: At what ages do investigators report observing particular conceptions of energy? To answer this question, we first needed to identify the range of conceptions reported in the literature.

Gilbert and Watts (1983) describe three clusters of energy (mis)conceptions (general conceptual frameworks) that can be derived from research into energy conceptions. These are the notions that energy: (1) has to do with living things; (2) makes things work; and (3) changes from one form to another. Nicholls and Ogborn (1993) provide a more detailed list:

1. energy as human or animate activity;
2. energy as a fuel;
3. energy as movement;
4. energy as force;
5. energy as an invisible fluid.

Trumper (1993) provides even more detail in his list:

1. Energy is something people have (anthropocentric framework).
2. Energy is something objects can have and lose.
3. Energy is the reason that some things happen (cause framework).
4. Energy is something objects do (or do not) have that can be released under the right conditions.
5. Energy is associated with activity or motion.
6. Energy is something that is created by certain events (product framework).
7. Energy is a generalized kind of fuel that can make life more comfortable.
8. Energy is viewed as a kind of fluid that can be transferred from one object to another.
9. Energy (as an abstract quantity) can be transferred from one system to another.

Guided by these lists and the insights of physical science teachers, we developed our own list, consisting of 11 conceptual categories. All of the items in our list are represented in the lists of Trumper (1993) and Gilbert and Watts (1983), though we have collapsed some categories, subdivided others, and included the complete scientific conception that energy is a quantity that is conserved.

1. Energy as a property of people or other living things;
2. Energy as a fuel—electricity, petrol, calories in food, etc.;
3. Energy as motion or activity;
4. Energy as a force or power;
5. Energy as a substance;
6. Energy as something that causes things to happen;
7. Energy as something that can be created;
8. Energy as something that comes in different forms;
9. Energy as something that can be transferred from one object to another;

10. Energy as something that can be converted from one form to another; and
11. Energy as a quantity that is conserved.

Table 1 shows the school grades at which investigators have reported observing these 11 conceptions. It is important to note that the research projects represented in this table did not attempt to describe all of the conceptions held by students. The empty cells do not mean that the students whose reasoning was being investigated did not hold those ideas. We present this table only to illustrate that the concepts we observed in this research project have been observed in other samples. Given the pervasiveness of these conceptual categories in the literature, it is interesting that no one has yet addressed the question of whether these conceptions represent different levels of understanding of the energy concept.

Energy Conceptions and Cognitive Development

Research shows that scientific concepts become increasingly abstract over the course of development (Carey, 1992; Case, 1991; Chi *et al.*, 1981). For example, Slotta and his colleagues (Slotta et al., 1995) compared the energy conceptions of 9th grade novices with those of graduate and post-graduate experts. They found that the conceptions of novices were tied to material substances while the concepts of experts were abstracted from specific substances.

Several researchers have reported a positive relation between the adequacy of students' scientific conceptions and level of cognitive development (Trumper, 1993). Only one of these studies examined energy concepts. For this study, Trumper (1993) first identified 9 conceptual frameworks—listed above—employed by group of 9th grade students who had received no formal physics instruction. After these conceptual frameworks had been identified, a new group of 29 students from ninth, tenth, and eleventh grade were tested to determine their cognitive developmental levels and identify their conceptual frameworks. Students were most likely to employ anthropocentric, cause, and product frameworks. Four months after receiving instruction on the energy concept, students were retested to determine whether they had learned and retained the new conception. The authors reported that: (1) the anthropocentric framework was unrelated to learning the energy concept; (2) students who employed the cause and product frameworks were more likely to learn the energy concept than those who did not and that this was true both of students who were pre-formal operational and those who were formal operational in their pre-instruction reasoning; and (3) students who were formal operational were more likely to learn the energy concept.

Developmental Maieutics

Dawson-Tunik's (2004a) approach to identifying sequences of conceptual development involves submitting interview data to at least two forms of qualitative analysis[i]. First, interview texts are independently analyzed for (1) their developmental level and (2) their conceptual content. Then the results of these analyses are examined together to identify trends in conceptual development. To conduct the developmental analysis, we evaluate the hierarchical structure (discussed further below) of reasoning performances. To conduct the content analysis, we interpret the specific meanings expressed in the same performances. Using this method, we have described developmental sequences for conceptions of leadership, good education, epistemology, learning, morality, and the self, as well as for critical thinking, decision-making, and problem-solving (Dawson, 2004; Dawson & Gabrielian, 2003; Dawson & Stein, 2004; Dawson-Tunik, 2004a, 2004b; Dawson-Tunik & Stein, 2004a, 2004b).

Hierarchical Development

Developmental levels, also referred to here as *orders of hierarchical complexity,* are conceived as a series of hierarchical integrations of knowledge structures. Many developmental theories employ the notion of hierarchical complexity. In the Piagetian model, for example, each successive hierarchical integration produces novel understandings by employing the operations of the previous order as conceptual elements in its new constructions. This notion is central to several other developmental theories as well, including those of Werner (1948), Case (1985), and Fischer (1980), and underlies a number of developmental scales, such as the levels and tiers of Fischer's (1980) skill theory and the stages of Commons' General Stage Model (Commons *et al.*, 1998).

The Lectical™ Assessment System (LAS)

Several attempts have been made to develop a generalized developmental assessment system for human raters. Indeed, Piaget defined each of his developmental stages in generalized terms. Conservation, for example, is a general feature of concrete operations and can be observed on a wide range of tasks. Case (Case *et al.*, 1992), Fischer (Fischer & Bidell, 1998; Rose & Fischer, 1989), and their colleagues have employed generalized definitions to scale performances across domains, but have not disseminated generalized scoring systems. Based primarily on Commons' General Stage Scoring System (Commons et al., 2000) and Fischer's skill theory (1980), the LAS (Dawson-Tunik, 2004b), employed in this study, lays out explicit general criteria for determining the developmental level of performances in any domain of knowledge.

The thirteen skill levels described by Fischer (Fischer & Bidell, 1998) and the first 13 of Commons' 15 stages are similarly defined. We employed the level names from Fischer's skill theory to label our complexity levels: (0) reflexive actions, (1) reflexive mappings, (2) reflexive systems, (3) single sensorimotor actions, (4) sensorimotor mappings, (5) sensorimotor systems, (6) single representations, (7) representational mappings, (8) representational systems, (9) single abstractions, (10) abstract mappings, (11) abstract systems, and (12) single principles/axioms.

When assessing the complexity level of a text with the LAS, the analyst refers to two manifestations of hierarchical complexity: its conceptual structure, embodied in the *hierarchical order of abstraction*[ii] of the new concepts employed in its arguments, and to the most complex *logical structure* of its arguments. These conceptual and logical structures are identical by definition and fundamentally interdependent. We make a distinction between the two types of structure for heuristic and pragmatic reasons. When scoring texts, hierarchical order of abstraction refers primarily to the structure of the elements of arguments, which often must be *inferred* from their meaning in context, whereas logical structure refers to the *explicit* way in which these elements are coordinated in a given text.

Each complexity order is associated with a hierarchical order of abstraction (reflexive actions, sensorimotor schemes, representations, abstractions, or principles) and one of 3 logical forms (elements, mappings or relations, and systems).

For a more complete account of the scoring system, see the methods section and the LAS web site (Dawson-Tunik, 2004b).

Reliability and Validity of the Scoring System

We have undertaken several studies of the reliability and validity of the LAS and its predecessors (Dawson, 2002, 2003, 2004; Dawson & Gabrielian, 2003; Dawson *et al.*, 2003; Dawson-Tunik, 2004a). We have examined inter-analyst agreement rates, compared scores obtained with the LAS with scores obtained with more conventional scoring systems, and examined the functioning of the scale through statistical modeling. Inter-analyst agreement rates have been high, 80% to 97% within half of a complexity level (Dawson, 2004; Dawson & Gabrielian, 2003; Dawson-Tunik, 2004a)[iii]. Correspondences between other developmental scoring systems and the LAS are also high, consistently revealing agreement rates of 85% or greater within ½ of a complexity level (Dawson, 2002, 2004; Dawson et al., 2003). Employing

Rasch scaling, which provides reliability estimates that are equivalent to Cronbach's alpha, we have consistently calculated reliabilities over .95 (Dawson, 2002; Dawson et al., 2003; Dawson-Tunik, 2004a). Overall, our research shows that the LAS is a valid and reliable general measure of intellectual development from early childhood through adulthood.

Method

Instrument

The interview instrument was the *Energy Teaser*[iv]*,* a worksheet that poses a series of questions about the energy of resting, rolling, and bouncing balls. Figure 1 depicts the bouncing ball problem. Students either filled out a paper form of the teaser or both filled out the teaser and participated in a clinical interview that probed their responses to the teaser.

-------------------------insert Figure 1 about here-------------------------

Procedures

Because our primary intentions in conducting our larger project were to describe the sequence of conceptual development for the energy concept and to employ what we learned to inform the design of lesson plans and scoring rubrics for teachers (rather than to test a hypothesis), we were able to employ an informal research design. This was fortunate, as constraints imposed by participating schools made it impossible to implement formal sampling procedures.

A total of 6 ninth grade teachers, all of whom were participants in the outreach and training program of the Collaboration for Excellence in Science Education at Hampshire College, agreed to administer the Energy Teaser before and after teaching the energy unit. The energy unit was approximately one week in duration and involved an activity observing and explaining energy state changes in bouncing balls. See the CESE web site for a complete description of this activity (Dawson-Tunik *et al.*, 2004). Teachers further agreed to allow researchers to spend one day prior to instruction and one day following instruction interviewing student volunteers from each of their physical science classes. At the post-instruction interviews (Time 2), every effort was made to meet with the students who had participated in the pre-instruction interviews (Time 3). Poor student attendance and the voluntary nature of participation made this difficult.

In order to describe a sequence of conceptual development, it is necessary to sample a wide age-range, preferably extending to the youngest age group that can reasonably complete a given interview. In part, this is because it is impossible to determine the developmental level at which concepts are first articulated without sampling down to a developmental level at which the concepts have not yet appeared. Consequently, although our target group was ninth grade students, we also interviewed a group of K-8 students, as reported below.

Sample

The distribution of students in the pre-instruction sample, which includes 50 grade 9 participants as well as 43 K-8 and 2 grade 11 participants (who were taking grade 11 physics), and the distribution of students in the post-instruction sample are shown in Table 2 (The three 10th grade students were repeating 9th grade physical science.). Although we attempted to interview the same 9th grade students before and after instruction, we met with limited success. Only 13 of the 49 grade 9 students interviewed at Time 1 were re-interviewed at Time 2. Fortunately, although we were able to interview only a small subsample of students, all of the students in participating classrooms were asked to fill out the Energy Teaser, resulting in a total of 119 grade 9 students who filled out both pre-instruction and post-instruction teasers. These teasers provided an additional gauge of developmental trends in students who were in attendance on the days in which the teasers were administered. Although we scored these teasers for their developmental level, we did not submit them to a content analysis because the interviews were a much richer source of content information.

-------------------------insert Table 2-------------------------

Developmental* A*nalysis

To assess the developmental level of the interviews and teasers, we employed the LAS. The LAS is based on a three-layer model of conceptual structure. In this model—illustrated in Figure 2—the outer layer represents *conceptual content*, the middle layer represents *domain-level structure*, and the inner layer represents *core* structure.

-------------------------insert Figure 2 about here-------------------------

The LAS targets core structures to determine the *complexity level* of a performance. These core structures are *hierarchical order of abstraction* and *logical structure*. Table 3 provides short definitions of each of the levels identified in the sample of interviews collected for this project, along with commonly reported modal ages of acquisition. See the LAS web site (Dawson-Tunik, 2004b) for more information about these constructs and examples of performances from each level in several knowledge domains.

-------------------------insert Table 3 about here-------------------------

Most other scoring systems target domain-level structures such as *sociomoral perspective,* in the moral domain, or forms of relativism, in the epistemological domain. Many of these scoring systems also target conceptual content. Moreover, domain-based scoring manuals are generally based on the conceptualizations of a small sample of respondents and are extremely expensive and time consuming to produce, which limits their generality and availability. The main advantage of these systems is that it is much easier to score using a system based on domain structure and conceptual content than it is to score with a system that focuses on hierarchical order of abstraction and logical structure. The former primarily involves matching the arguments made by a respondent with exemplars in a scoring manual. The latter involves an examination of the deep structures implicated in the meanings conveyed by a given text.

It is not possible to fully describe our scoring procedures in this short section, as it takes many hours of instruction and practice to become an accurate LAS analyst. To obtain a basic understanding of how LAS analysts assign a score, refer to Table 3 and the LAS web site (Dawson-Tunik, 2004b). Scores are based on hierarchical order of abstraction and logical structure, and analysts must understand how these manifest in a given performance. Scoring is an iterative process; the analyst alternately examines each layer of structure until he or she converges on an interpretation of the core structure of the performance. For example, an analyst was asked to score the following interview segment:

> [*Could you have a good life without having had a good education?*] Yeah, probably so, I would say. I wouldn't...it would be richer with education, but it wouldn't... [*Why do you think it would be richer with education?*] Well, you just, your mind would be open to a lot more things (Dawson-Tunik, 2004a, case 0212).

The analyst's response illustrates how each layer of structure plays a role in the scoring process:

> Well, this isn't a very sophisticated notion of the role of education in the good life. Especially because, at first, I thought that he was saying that you'd be richer, money-wise (laughter), with an education. That would make "richer" a [representational] notion, but I see that it's actually at least abstract, because it's related to this idea of open-mindedness. It seems there are two variables [richer life, open mind] that are in a logical relation to one another…as in, "If you get a good education, your mind will be more open, and therefore you will have a richer life." This would make it at least [abstract mappings], but could it be

> higher than that? Well, *richer life* could be higher than [single abstractions], and so could *open mind*, so I'm looking for evidence that they are…but the perspective here is of the individual person and his life, without bringing in anyone else's perspective, or a social perspective, so you can't say, really. [Abstract mappings]; I'll stick with that (Dawson-Tunik, 2004a).

In this example, the analyst appeals to all three levels of structure. The content level is referenced in her initial attempt to understand the argument, and again when she double checks her understanding at the end. The domain structure level is briefly included when she examines the social perspective of the respondent to see if there are grounds for considering the possibility that the statement is at a higher level than abstract mappings. The core structure is reflected in her analysis of the hierarchical order of abstraction and logical structure of the argument.

From this example, it is clear how *meaning* is central to the scoring process. Without a correct interpretation of the meaning of a statement, the analyst cannot even begin the process of scoring. In this case, knowing which sense of *richer* is intended by the respondent is essential to a correct interpretation of the hierarchical order of abstraction of the concept.

---------------------insert Table 4 about here---------------------

Interview scoring. Before scoring the responses to the energy interview, the interviews were divided into segments, or *protocols*, by probe question. There were 1 to 7 protocols per interview, depending upon the age group. Younger respondents, due to attention span issues, generally received only the bouncing ball question. Each protocol was scored with the LAS, employing the 5 phase version of the scoring system. In this version, the analyst not only states the level of a protocol, but one of 5 phases: transitional into the level, unelaborated, elaborated, highly elaborated, or transitional out of the level. A mean score was calculated for each respondent. The levels identified ranged from elaborated representational mappings to abstract mappings.

Teaser scoring: Teasers were awarded a single complexity level score, employing the two phase version of the LAS in which the analyst not only assigns a level score, but also indicates whether the performance is unelaborated or elaborated at a given level. We awarded a holistic score because the responses to individual questions were too short to permit us to score them individually. We employed the two phase version of the LAS because scoring accuracy is weakened when only one score is awarded to a given text, reducing the reliability of more finely tuned assessments.

LAS analysts are required to maintain an agreement rate of 85% within 1/3 of a complexity level with a Certified Master LAS analyst. All of the interviews were initially scored by the second author. The first author scored a subset of 71 protocols. The agreement rate between the first author and the second author was 75% within 1/5 of a complexity level, 92% within 2/5 of a complexity level, and 97% within 3/5 of a complexity level. There were no disagreements greater than 1 complexity level. Kendalls tau b was .87.

Content* A*nalysis

The interviews were coded for their conceptual content by one trained undergraduate student coder. The coder was provided with a lengthy concept list that had been developed by the first author following an initial analysis of the content of a representative sub-sample of the interviews. The coder was instructed to code every relevant concept in each interview, preferably assigning one of the codes in the original list. In cases where there was no existing code that closely represented the meaning being conveyed by a respondent, the coder created a new code. Coders maintained high degree of specificity. For example, there were separate codes for the notions that energy cannot be lost, is always conserved, and can neither be created nor destroyed. By preserving fine distinctions in meaning, we optimized our ability to detect sometimes subtle changes in meaning.

New codes were incorporated subject to the agreement of the first author, who also assessed the consistency of coding at frequent intervals throughout the coding process. Analysts were occasionally asked to change or add coding categories following these assessments. In the end, there were 206 coding categories, and a total of 2405 codes were awarded to the 139 interviews collected for the study. The first author also conducted a check of codes awarded to a randomly selected sample of 10% (14) of the interviews following the completion of coding. A total of 235 codes were checked. There were 6 cases in which the first author disagreed with a code awarded by the analyst and 7 cases in which the first author would have awarded an additional code. This is a satisfactory rate of disagreement.

The first step of the concept analysis was to order concept codes by the developmental levels at which they first occurred in performances (as shown in Appendix A). Trends were analyzed by isolating the most commonly identified conceptions at each level and making comparisons across test times and developmental levels. We then examined trends in these codes along 3 thematic strands: (1) kinetic and potential energy, (2) energy transfer, and (3) the relation between energy and gravity. This process involved identifying the concept codes that were relevant to each strand (codes could be relevant to more than one strand), then examining the interviews in which the concepts appeared to determine how they were employed in context. Finally, for each strand, we developed descriptions of reasoning at the elaborated phases of each developmental level represented in the data in order to provide a coherent summary of general trends in the development of reasoning about energy. We chose elaborated performances because these tend to be the performances in which the conceptions of a given level reflect the structures of that level (Dawson & Gabrielian, 2003; Dawson-Tunik, 2004a).

Results

Developmental Analysis

Pre and post analysis. The comparison of complexity level scores at Time 1 and time 2 was conducted as a validation of the scoring system. We expected the learning intervention to result in small but measurable positive changes in the mean developmental level of performances. If our developmental assessments capture change of this kind, we can be more confident in constructing a developmental sequence on the basis of our analysis.

Interviews. Table 4 shows the distribution of pre-instruction complexity level scores for 95 interviews by school grade. Mean scores increased significantly with educational attainment, r = .83, $p < .05$. Sex did not explain any additional variance in developmental scores after education was taken into account.

Table 4 also shows the distribution of post-instruction scores for 44 students by school grade. Sex did not explain any variance in developmental scores.

-------------------------insert Table 4 about here-------------------------

As shown in Table 5, of the 13 students who were interviewed before and after the energy unit was presented, 4 demonstrated no measurable developmental change, 1 demonstrated a regression, and 8 demonstrated developmental progress. Average gain was about 1/5 of a complexity order. This trend was statistically significant, (M = 1.09, SD = .97, $t(12) = 4.07$, $p < .01$).

-------------------------insert Table 7 about here-------------------------

Teasers. As shown in Table 6, of 119 students who filled out teasers before and after the energy unit was presented, 80 demonstrated no measurable developmental change, 8 demonstrated developmental regressions, and 31 demonstrated developmental progress.

Average gain was about ¼ of a complexity order. The positive trend was statistically significant, (M = .50, SD = 1.31, $t(118) = 4.14$, $p < .05$).

Trends in the interview and teaser data show that developmental progress was in the direction specified by our developmental model. This evidence provides support for a description of the sequence of conceptual development based on the hierarchical ordering of performances in the cross-sectional sample.

-------------------------insert Table 6 about here-------------------------

Content analysis

Conceptions expressed in pre-instruction interview (Time 1). The concept analyses were based on the entire sample of interviews, divided into those that occurred at Time 1 and those that occurred at Time 2. We are not concerned here with the fact that these are unpaired samples, because the purpose of comparing conceptions found in the pre- and post-interviews is to assess the general direction of learning, not to evaluate the quality of the learning intervention. To facilitate presentation of the results from the concept analysis, each case was assigned a whole complexity level score of representational mappings, representational systems, single abstractions, or abstract mappings. Table 7 shows the distribution of scores for pre- and post-interviews.

-------------------------insert Table 7 about here-------------------------

In this section we describe the most common conceptions encountered at the four developmental levels at Time 1. A conception was considered common if it appeared in more than 30% of performances. The choice of 30% was somewhat arbitrary. The main goal in selecting this value was to reduce the concept lists to a manageable length without losing too much valuable information.

At the representational mappings level, respondents primarily described the anticipated activity of the ball with no reference to its energy. Of 11 students performing at the representational mappings level, only 2 (18%) respondents mentioned energy, and these were references to people having energy—to run, play, work, etc. Five (46%) asserted that the ball would bounce after being dropped because it was bouncy, and 5 (46%) asserted that the ball bounced because it could only go up after hitting the floor.

At the representational systems level, *energy* is occasionally mentioned by respondents, but it is either synonymous with the movement of the ball or a kind of force or pressure. Of 21 students performing at the representational systems level, 7 (33%) asserted that balls bounce because they are bouncy or squishy, 9 (43%) asserted that balls bounce because they are made of bouncy stuff, and 9 (43%) explained that the ball bounced because it was being pulled or pushed by gravity.

At the single abstractions level, the focus moved away from describing the activity of the ball to describing its energy. Of 41 respondents performing at this level, 16 (39%) argued that the energy of the ball increased during its fall, 15 (37%) argued that energy increased with the speed of the ball, and 13 (32%) argued that the energy of the ball decreased after a bounce. Gravity was viewed by 28 (68%) respondents performing at this level as a force that pulls or pushes the ball. Only 5 (12%), 2 (5%), 3 (7%), and 3 (7%) respondents performing at this level mentioned potential, kinetic, light, or heat energy (respectively).

Twenty-two of the interviews were scored at the abstract mappings level, where conceptions were considerably more differentiated than at earlier levels. Although many of the notions that appeared at earlier levels persisted, several new notions became dominant. Eight respondents (36%) asserted that the energy of the ball decreased when it bounced, and 8 (36%) asserted that the energy of the ball increased during its fall. Eight (36%) students explained that during its fall the *speed* of the ball would increase due to gravity, 9 (41%) asserted that the *energy* of the ball would increase due to gravity, and 9 (41%) claimed that the energy of the ball would decrease as it bounced because of friction or air resistance. Respondents were also likely to mention kinetic (10, 45%) or potential (11, 50%) energy, and 10 (45%) expressed the notion that some of the energy of the ball would be transferred to the floor at the moment of impact (10, 45%). Light (2, 9%) and thermal (2, 9%) energy were rarely mentioned.

Comparison of conceptions expressed in pre-instruction interviews (Time 1) with those expressed post-instruction (Time 2). There were several changes in conceptions on the post-instruction interviews. First, there were no representational mappings performances and only one representational systems performance in the post-instruction group. This is primarily because the sample at Time 2 was restricted to students in the grade 9 physical science classrooms. We consequently examined only the conceptions at the levels of single abstractions and abstract mappings. Second, while some concepts were present in similar proportions at Time 1 and Time 2, some concepts lost prominence at Time 2. Third, several concepts that had been represented in fewer than 30% of the interviews at Time 1 occurred in more than 30% of the interviews at Time 2.

As shown in Table 8, one single abstractions level concept lost prominence at Time 2: the notion that gravity pushes or pulls on a bouncing ball. Instead of making this claim about gravity, students were more likely to claim that gravity is related to energy in a general sense. Conceptions that were common at Time 1 that became more common at Time 2, include the notion that the energy of a ball decreases when it bounces, increases during its fall, and is associated with the speed of the ball. Concepts that became common at Time 2 included the notions that the speed of a ball increases as it falls, that gravity is related to energy, that the energy of a bouncing ball can be transferred to the floor, that energy can be gained or lost, that energy is always present. Furthermore, at Time 2 students performing at this level were more likely to mention kinetic energy and to describe energy in terms of force. Concepts that were present at both single abstractions and abstract mappings are italicized in the table.

-------------------------insert Table 8 about here-------------------------

At the abstract mappings level, 5 concepts lost prominence at Time 2: the notions that gravity pulls or pushes on a bouncing ball, gravity is related to energy, the energy of the ball increases as it speeds up, the energy of the ball decreases when it bounces, and there is no energy in the absence of movement. As shown in Table 9, several concepts occurred at abstract mappings in similar proportions at Time 1 and Time 2, including the notions that the velocity of a falling ball is affected by gravity, the energy of a ball increases during its fall, the energy of a ball increases because of gravity, the energy of a ball can be transferred to the floor, and the energy of a ball is decreased by friction. Though students commonly mentioned kinetic and potential energy at Time 1, they were almost twice as likely to mention these two forms of energy at Time 2. Finally, numerous concepts became common after instruction that were relatively rare before instruction. These included the notions that energy can be lost, energy is in everything, energy can be transferred from one object to another, some of the ball's energy is changed to sound, the energy of the ball changes as it bounces, the speed of the ball is increased by the fall, some of the ball's energy is changed to heat energy, energy can be stored in an object, friction slows a bouncing ball, and energy is always present. In addition, at Time 2 it was more likely that energy would be associated with speed, defined in terms of work, or described in terms of force, and students were more likely to offer definitions for kinetic and potential energy. Concepts that were present at both single abstractions and abstract mappings are italicized.

-------------------------insert Table 9 about here-------------------------

Table 10 compares the post-instruction incidence of conceptions in single abstractions and abstract mappings performances. The distribution of concepts indicates that individuals performing at single abstractions do know as much about energy as students performing at abstract mappings, and that in some cases, they appear to learn things that are incorrect.

At the abstract mappings level, students are more likely to discuss energy transfer and transformations than they are at the single abstractions level. They are more likely to explicitly claim that the energy of the ball changes as it falls and to implicate friction as a factor in this process. They are also more likely to state that energy is in everything, state that energy can be stored, state that energy is always present, define energy in terms of work, mention potential or kinetic energy, and provide definitions for potential and kinetic energy.

-------------------------insert Table 10 about here-------------------------

Descriptions of developing conceptions of energy along 3 thematic strands

Although the above tables provide interesting insights into the differences between energy conceptions at the four complexity levels and before and after instruction, they do not describe the general way in which energy concepts change from level to level. Here we reintegrate structure and content to present an account of how energy conceptions develop along 3 thematic strands: (1) kinetic and potential energy, (2) energy transfer, and (3) the relation between energy and gravity. Tables 13 through 15 provide descriptions of reasoning on these thematic strands for the elaborated phases of 4 developmental levels. They also describe clear progressions in the development of energy conceptions and related constructs.

-------------------------insert Tables 13-15 about here-------------------------

At the representational mappings level, children generally lacked a conception of energy, rarely used the word, and never used it with reference to the activity of a ball. All of the children performing at this level described aspects of the movement of the ball, many observing that the ball would eventually stop bouncing, and a few mentioning gravity as something that pulls or pushes on a ball.

At the representational systems order, many children provided elaborate observations of the movements of a bouncing ball. Most observed that a bouncing ball bounces lower and lower. Children performing at this level were more likely than children performing at the abstract mappings level to employ the term energy, but their use of the term indicated that energy and motion were undifferentiated. To these children, more or faster motion meant more energy. Some children performing at this level used *gravity*—meaning something that pushes or pulls—as an explanation for the successively lower bounces of the ball.

At the single abstractions level, we observed the first uses of the term energy as something "behind" motion—as a cause for motion. Some students performing at this level employed the terms kinetic or potential energy, though their use of the term *potential energy* indicated that they did not think of it as a form of energy, but rather as a potential for energy to happen. At this level, some students also spoke of energy transfer, explaining that the energy of the ball transferred to the floor during a bounce, much as a liquid flows from one location to another. Gravity was seen as a force that gradually takes away all of a bouncing ball's energy.

At the abstract mappings level, kinetic and potential energy were finally understood as different energy states. Students performing at this level described transformations from one state to the other, sometimes even referring to types of potential energy. Energy transfer was conceptualized as a change of energy from one form to another, as in a change of energy as motion to energy as heat or sound. Gravity was classified as a constant force that provides objects with potential energy in some situations and kinetic energy in others.

Although students performing at the abstract mappings level demonstrated a basic understanding of kinetic and potential energy and could describe energy transfer, they were unable to coordinate notions of energy transformation with notions of energy transfer to describe a system in which energy is conserved. The inability to coordinate notions of energy transformation and energy transfer leads to incorrect assertions like the example in Table 10, in which the student performing at abstract mappings claims that the energy of a ball is conserved because only energy transformations have occurred. In fact, because an understanding of energy conservation involves the simultaneous coordination of multiple abstractions—those relevant to both energy transfer and energy transformation—in a system of relations, we would not expect a complete understanding of this concept until the abstract systems level. Because abstract systems has rarely been identified as the modal level in any knowledge domain before the age of 20 (with three years of college), we did not expect students in this sample to demonstrate a complete understanding of energy conservation.

Discussion

Most constructivist research on the development of scientific conceptions describes two types of conceptions—misconceptions and correct conceptions. Researchers have consistently reported that misconceptions are difficult to replace with correct conceptions and that learning accurate physics conceptions is arduous. Given these difficulties, Warren (1986) has gone so far as to argue that the energy concept should not be taught at all until high school, when students are able to reason abstractly. Trumper's (1993) observation that adequate energy conceptions were associated with formal operations seems to support this view. However, others, based on the same evidence, have suggested teaching these concepts in stages, so that students can construct increasingly adequate conceptions (Watts, 1983).

We have not found prior evidence of a described sequence for the development of the energy concept. One likely reason for this is that there has not been a reliable method for assessing the developmental level of performances in the science domain, which means that most studies of the development of scientific conceptions have either used age as a proxy for development or used Piagetian tasks to assess developmental level. Both approaches have weaknesses. Because children develop at different rates, age can be misleading, and Piagetian tasks may or may not assess reasoning in the domain under investigation. This is important, given that it is well established that individuals may function at different developmental levels in different knowledge domains—even on different tasks within a single knowledge domain (Fischer & Bidell, 1998).

Another reason for the current lack of a described sequence is that the notion of a general developmental sequence is widely rejected among researchers investigating the development of scientific conceptions, and even those who accept that there may be a general developmental sequence often reject the idea that such a sequence could be useful in investigating the development of scientific conceptions.

The results of this project suggest that a general developmental model can be a valuable part of a methodology for investigating the development of scientific conceptions. Not only do we identify the same concepts that have been identified by other researchers, but we have been able to show that they appear to develop sequentially. The sequence indicates that some conceptualizations that have previously been broadly labeled as misconceptions, such as the association of energy with movement, may instead be precursors to increasingly adequate conceptions. Furthermore, the sheer number of precursor concepts that appear to form the basis for an eventual understanding of the scientific energy concept helps to explain why it is so difficult to attain this understanding. Finally, the pre-instruction and post-instruction assessments of developmental level imply that the developmental level of students prior to instruction has a major impact on what they learn.

The findings presented here corroborate Warren's (1986) assertion that an understanding of the scientific energy concept requires abstract reasoning, but does not suggest that we embrace his conclusion that the energy concept should not be taught before abstract reasoning is attained. Rather, it suggests that the energy concept is constructed through a hierarchical sequence of increasingly adequate conceptions, beginning with observations about the behavior of moving objects in the everyday world. We suggest that these observations, rather than interfering with the development of more advanced concepts, provide a *basis* for these more advanced concepts. This conclusion is in keeping with Smith and diSessa's (1993) re-conceptualization of misconceptions as preconceptions. In the present case, the conflation of energy and movement (often characterized as a misconception), first observed at representational systems, precedes the differentiation of energy and movement, which begins at single abstractions with the notion that energy is something "behind" motion, and continues at abstract mappings with the notion that kinetic and potential energy are alternating energy states. This is not only the observed progression, but it is a logical progression of increasing differentiation. None of these conceptions should simply be construed as a misconception; each is a necessary building block in the process of constructing increasingly adequate conceptions.

We agree with White (1993) and Metz (1997), who have argued that partial understandings of cognitive developmental theories, particular Piagetian theory, sometimes have inappropriately influenced science education. For example, some researchers have used evidence from children's performances on Piagetian tasks to justify restricting early science learning to seriation, measurement, and concrete manipulations of the material world. We do not advocate this view.

Although our findings suggest that there is an order to the acquisition of energy concepts that is both empirically verifiable and logical, and that movement to a new level may require some level of mastery of the current level, there is nothing in our findings that suggests that younger children cannot benefit, for example, from learning basic inquiry and metacognitive skills. Good observation and reasoning skills are required for optimal learning (Davidson et al., 1994; Metz, 1997; B. Y. White & Frederiksen, 2000), though these are also subject to developmental constraints (Flavell, 1979; Kreutzer et al., 1992). What our work does suggest is that learning scientific concepts is a slow process, and that students may best understand the concepts that are presented in a way that is consistent with their developmental level.

Whereas 62% of the 13 students who were interviewed at Time 1 and Time 2 demonstrated developmental progress, only 26% of students who filled in pre- and post-instruction teasers demonstrated developmental progress. Moreover, the concepts of students who performed at the level of single abstractions changed—though not into the conceptions in their text books. They changed into single abstractions versions of these conceptions.

The sample collected for this project is far from representative. It is a convenience sample, and our results should therefore be interpreted with some caution. We regard this project as a first step in describing the development of scientific conceptions. Future work should include more diverse samples, more longitudinal evidence, and experimentation with different types of learning interventions. Despite the shortcomings of the sample, the evidence presented here succeeds in demonstrating the value of a methodology that incorporates a general measure of cognitive development, and provides evidence for a sequence in the development of energy conceptions.

Appendix A: Concept codes and their occurrence by developmental level

Code	**RM%**	**RM**	**RS%**	**RS**	**SA%**	**SA**	**AM%**	**AM**
States that ball bounces	81.82%	9	63.64%	14	23.29%	17	18.18%	6
States that ball bounces because it is bouncy/squishy	45.45%	5	31.82%	7	5.48%	4		
States that ball bounces because it can only go up	45.45%	5	9.09%	2	2.74%	2		
States that the ball bounces because it hits the floor/ground hard	18.18%	2	18.18%	4	5.48%	4		
States that the air makes balls bounce	18.18%	2	18.18%	4	2.74%	2	6.06%	2
Energy is something people have	18.18%	2	4.55%	1				
States that the energy of the ball is decreased during fall	18.18%	2			17.81%	13	9.09%	3
States that ball bounces because it is made of a bouncy substance	9.09%	1	45.45%	10	17.81%	13	12.12%	4
Observes that falling ball falls/drops/goes down	9.09%	1	22.73%	5	8.22%	6	3.03%	1
States that ball stops	9.09%	1	9.09%	2	17.81%	13	33.33%	11
States that ball height gets lower on every bounce	9.09%	1	9.09%	2	10.96%	8	24.24%	8
States that the weight of a ball will affect how well it bounces	9.09%	1	9.09%	2	9.59%	7		
States that ball will not bounce back up to where it was dropped from	9.09%	1	4.55%	1	17.81%	13	27.27%	9
States that ball bounces because the floor is hard	9.09%	1			2.74%	2		
States that ball cannot be stopped while in motion	9.09%	1			1.37%	1		
States that a heavy ball will fall faster	9.09%	1			1.37%	1		
States that amount of bouncing depends on height of drop	9.09%	1			1.37%	1		
States that speed stays at a steady rate during fall	9.09%	1			1.37%	1	3.03%	1
States that bounce is affected by way it is dropped	9.09%	1						
States that ball cracks when it hits the floor	9.09%	1						
States that balls bounce because that is what balls do	9.09%	1						
States that energy is what makes the ball bounce			22.73%	5	23.29%	17	6.06%	2
States that gravity pushes			22.73%	5	16.44%	12	15.15%	5

States that gravity pulls/holds			18.18%	4	46.58%	34	69.70%	23
Energy is associated with motion/movement			18.18%	4	42.47%	31	60.61%	20
Energy is associated with pushing			18.18%	4	39.73%	29	45.45%	15
Energy is associated with speed			13.64%	3	54.79%	40	36.36%	12
General statement that gravity makes the ball go down/hit the ground			13.64%	3	6.85%	5	9.09%	3
States that the energy of the ball is decreased by a bounce			9.09%	2	43.84%	32	33.33%	11
Estimates the height the ball will return to after a bounce			9.09%	2	17.81%	13	6.06%	2
Claims that bounce height is affected by the dropping method			9.09%	2	1.37%	1		
States that bounce height is affected by gravity			9.09%	2	1.37%	1	3.03%	1
States that the energy of the ball increases as it speeds up			4.55%	1	30.14%	22	24.24%	8
States the speed of the ball is increased by the fall			4.55%	1	28.77%	21	30.30%	10
States that energy can be transferred to the floor					21.92%	16	42.42%	14
General statement that gravity is related to energy					20.55%	15	18.18%	6
States that the energy of the ball will be increased by bounce					12.33%	9		
States that the energy of the ball is decreased due to gravity					12.33%	9	12.12%	4
Energy comes from the person			4.55%	1	12.33%	9	12.12%	4
Energy is associated with pressure					10.96%	8	6.06%	2
States that ball slows down			4.55%	1	10.96%	8	15.15%	5
States that force pushes			4.55%	1	9.59%	7	6.06%	2
States that energy can be stored in something					9.59%	7	21.21%	7
Energy is associated with pulling			4.55%	1	8.22%	6	3.03%	1
Defines kinetic energy					8.22%	6	30.30%	10
States that ball will eventually stop bouncing			4.55%	1	6.85%	5	6.06%	2
Energy is associated with power			4.55%	1	5.48%	4	6.06%	2
States that the energy of the ball changes					5.48%	4	21.21%	7
General claim that energy is in everything					4.11%	3	18.18%	6
States that the energy of the ball is decreased by floor/impact			4.55%	1	4.11%	3	12.12%	4
Statement that gravity pulls objects toward the center of the					4.11%	3	12.12%	4

earth									
States that energy can't last forever/eventually goes away					4.11%	3	6.06%	2
States that bounce height is affected by the substance of which the ball is made			4.55%	1	4.11%	3	3.03%	1
Indicates that force causes motion			4.55%	1	4.11%	3		
States that bounce height is dependent on the height of the drop			4.55%	1	2.74%	2	9.09%	3
States that energy has been used up/wears off			4.55%	1	2.74%	2	3.03%	1
Mentions electrical energy					2.74%	2	3.03%	1
States that that bounce height is affected by the weight of the ball			4.55%	1	2.74%	2		
States that the energy of a ball is affected by its composition					2.74%	2		
States that bounce height is affected by the energy of the ball			4.55%	1	1.37%	1	3.03%	1
Floor is dented when the ball hits			4.55%	1	1.37%	1		
States that dropped objects will not bounce up to original height in the absence of force			4.55%	1	1.37%	1		
States that ball bounces because gravity can't hold it down			4.55%	1	1.37%	1		
States that the ball bounces because it is hollow			4.55%	1	1.37%	1		
States that gravity cannot hold the ball up			4.55%	1				
States that force decreases after impact			4.55%	1				
States that the ball spins as it falls			4.55%	1				
States that the ball and the floor have force			4.55%	1			3.03%	1
States that the energy of the ball will be greater on hill/incline than on flat surface					68.49%	50	57.58%	19
States that the energy of the ball increases during its fall					47.95%	35	36.36%	12
Describes energy in terms of force					34.25%	25	21.21%	7
States that energy is always there/present					31.51%	23	45.45%	15
States that energy can be removed/lost					30.14%	22	15.15%	5
States that energy is absent if there is no movement					30.14%	22	9.09%	3
States that the energy of the ball					23.29%	17	39.39%	13

increases because of gravity								
Mentions potential energy					19.18%	14	63.64%	21
States that velocity/speed is affected by gravity					19.18%	14	36.36%	12
Mentions kinetic energy					16.44%	12	57.58%	19
States that the energy of the ball is decreased as the ball slows down					15.07%	11	3.03%	1
Indication that gravity is understood as a force					13.70%	10	21.21%	7
States that energy is released/let go of by ball					12.33%	9	15.15%	5
States that energy is inside the ball					12.33%	9	21.21%	7
States that the energy of the ball is decreased by friction					9.59%	7	42.42%	14
Defines potential energy					8.22%	6	33.33%	11
States that friction will slow down a ball					8.22%	6	30.30%	10
Mentions heat/thermal energy					8.22%	6	12.12%	4
Energy is associated with air					8.22%	6	3.03%	1
States that the energy of the ball is decreased by impact/bounce					8.22%	6		
States that energy can be transferred from one object to another					6.85%	5	27.27%	9
Energy is associated with/defined in terms of work					6.85%	5	18.18%	6
States that energy is absent if there is no push					6.85%	5	9.09%	3
States that the energy of the ball decreases because of air					6.85%	5	6.06%	2
States that energy can be reversed					6.85%	5	3.03%	1
States that energy is absent during fall					6.85%	5		
States that momentum is present during fall					5.48%	4	9.09%	3
States that the ball bounces slower and slower with each bounce					5.48%	4	6.06%	2
Energy is associated with momentum					5.48%	4	3.03%	1
Mentions momentum					5.48%	4	3.03%	1
States that the energy of the ball will be increased by higher drop					5.48%	4	3.03%	1
States that the speed of the ball is decreased by impact					5.48%	4		
Energy is associated with strength					5.48%	4		
Describes action/reaction chain					5.48%	4		
States that energy slows down					5.48%	4		

States that force makes the ball bounce					5.48%	4		
States that some of the ball's energy is changed to sound energy					4.11%	3	18.18%	6
Mentions sound energy					4.11%	3	12.12%	4
Employs the term acceleration					4.11%	3	6.06%	2
States that the energy of the ball does not change as it falls					4.11%	3	3.03%	1
States that the force of gravity increases as ball falls/rolls down					4.11%	3	3.03%	1
General claim that there are different forms of energy					4.11%	3	3.03%	1
Mentions light energy					4.11%	3		
States that air resistance will slow down a ball					2.74%	2	15.15%	5
States that energy can be added or gained					2.74%	2	12.12%	4
States that ball wants to act in a certain way					2.74%	2	12.12%	4
Mentions Newton's laws					2.74%	2	12.12%	4
Employs term air resistance					2.74%	2	9.09%	3
States that energy just leaves/evaporates/disappears					2.74%	2	6.06%	2
Employs term action/reaction					2.74%	2	3.03%	1
States that momentum and speed are related.					2.74%	2	3.03%	1
Conceptualizes air resistance as wind (e.g., blow ball off course)					2.74%	2	3.03%	1
States that dropped objects automatically bounce					2.74%	2		
States that ball keeps moving					2.74%	2		
Employs term air pressure					2.74%	2		
States that some of the ball's energy is changed to heat energy/thermal					1.37%	1	24.24%	8
States that some of the ball's energy is changed to kinetic energy					1.37%	1	21.21%	7
Provides formula for acceleration					1.37%	1	18.18%	6
States that ball accelerates/speeds up while falling					1.37%	1	9.09%	3
States that the mass of the ball causes it to bounce					1.37%	1	9.09%	3
General claim that the energy of the ball decreases/is lost/ runs out					1.37%	1	6.06%	2
States that floor pushes the ball up					1.37%	1	6.06%	2
States that energy is released by					1.37%	1	6.06%	2

movement								
Mentions friction					1.37%	1	6.06%	2
States that the speed of the ball is affected by the height from which it is dropped					1.37%	1	6.06%	2
States that velocity/speed is affected by friction					1.37%	1	3.03%	1
Describes the consequences of air pressure					1.37%	1	3.03%	1
States that bounce height is affected by the type of ball (baseball, tennis ball, bowling ball)					1.37%	1	3.03%	1
States that momentum can be taken away/transferred					1.37%	1	3.03%	1
States that gravity wants the ball to stay/go down					1.37%	1	3.03%	1
States that energy can be transferred into the air					1.37%	1	3.03%	1
States that force decreases after the bounce					1.37%	1	3.03%	1
States that some of the ball's energy is changed to vibration energy					1.37%	1	3.03%	1
Discussion of limits of definition of potential energy							3.03%	1
States that the energy of the ball is decreased by shaking/vibration					1.37%	1		
States that energy is regained					1.37%	1		
States that the ball can't bounce high because there is nothing pushing on it					1.37%	1		
Mentions terminal velocity					1.37%	1		
Energy is under the ball					1.37%	1		
States that the energy of a bouncing ball is (partially) absorbed by the floor/goes into ground					1.37%	1		
States that friction speeds the ball up					1.37%	1		
States that force pulls					1.37%	1		
Energy is associated with light					1.37%	1		
States that the energy of the ball will be increased by floor/impact					1.37%	1		
Energy is associated with living things/ being alive					1.37%	1		
States that the floor slows the ball					1.37%	1		

States that the ball collides with gravity					1.37%	1		
General statement that energy is absent					1.37%	1		
States that force increases after impact					1.37%	1		
States that ball bounces off of the floor because of the density of the floor compared to the density of the ball					1.37%	1		
States that the energy of the ball is decreased by shock					1.37%	1		
States that the energy of the ball will be greater in a heavier ball					1.37%	1		
States that the ball bounces because of momentum					1.37%	1		
States that energy can be invisible					1.37%	1		
States that the energy of the ball will be less in a heavier ball					1.37%	1		
General claim that the energy of the ball increases					1.37%	1		
States that some of the ball's energy is changed to potential energy							21.21%	7
General statement that friction is related to energy							15.15%	5
States that energy can't be lost							12.12%	4
States that friction creates heat/thermal energy							12.12%	4
States that energy is invisible							9.09%	3
Mentions gravitational potential energy							9.09%	3
General statement that gravity is related to friction							9.09%	3
States that potential energy is related to gravity							9.09%	3
Mentions elastic potential energy							9.09%	3
States that the energy of the ball is decreased by sound							6.06%	2
Defines elastic potential energy							6.06%	2
States that the ball has force							6.06%	2
States that gravity helps ball move							6.06%	2
States that energy is conserved							6.06%	2
Describes the flattening of the ball when it hits the ground							6.06%	2
Defines terminal velocity							3.03%	1
General statement about a net							3.03%	1

force								
States that gravity is stronger after the ball bounces							3.03%	1
States that the ball does not have time to reach its terminal velocity							3.03%	1
States that the energy of the ball is decreased by inertia							3.03%	1
States that the floor causes the ball to change direction							3.03%	1
States that energy is absent if there is no pressure							3.03%	1
States that two sources or types of energy can cancel each other out							3.03%	1
States that the energy of the ball is decreased because of heat							3.03%	1
Defines gravitational potential energy							3.03%	1
Mentions inertia							3.03%	1
States that potential energy causes the bounce							3.03%	1
States that the ball is more stable when it has potential energy							3.03%	1
States that energy of motion can be transferred to friction							3.03%	1
Defines vibration energy							3.03%	1
States that air resistance is a form of friction							3.03%	1
Defines inertia							3.03%	1
States that some of the ball's kinetic energy (energy of motion) is changed to heat energy by friction							3.03%	1
States that gravity increases momentum							3.03%	1
States that gravity absorbs energy							3.03%	1
States that energy can't be created or destroyed							3.03%	1
States that the energy of the ball does not change with motion							3.03%	1
States that energy is absent at the moment of a bounce							3.03%	1
States that there are different types of force							3.03%	1
States that inertia helps the ball move							3.03%	1
Parses out effects of friction/air reisistance							3.03%	1

States that friction is a force							3.03%	1
Total		**11**		**22**		**73**		**33**

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Figure 1: Bouncing ball problem from the *Energy Teaser*

The ball in the drawing on the right is dropped onto the floor from a height of 100 centimeters. It then bounces to a height of 50 centimeters.

(g) Explain your theory of what is happening to the energy of the ball as it is falling.

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(h) Explain your theory of what happens to the energy of the ball at the moment when it hits the floor.

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(i) Explain your theory of what happens to the energy of the ball after it hits the floor.

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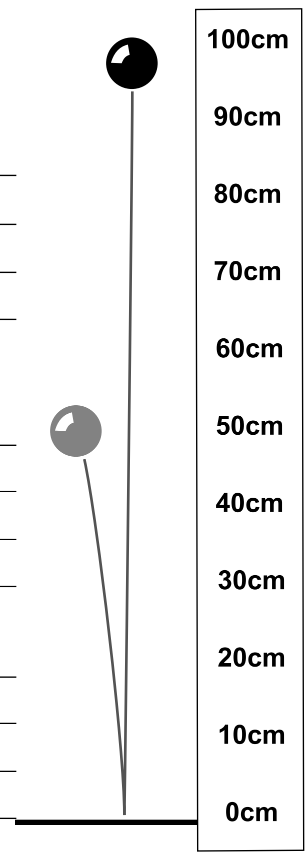

Figure 2: Layers of structure

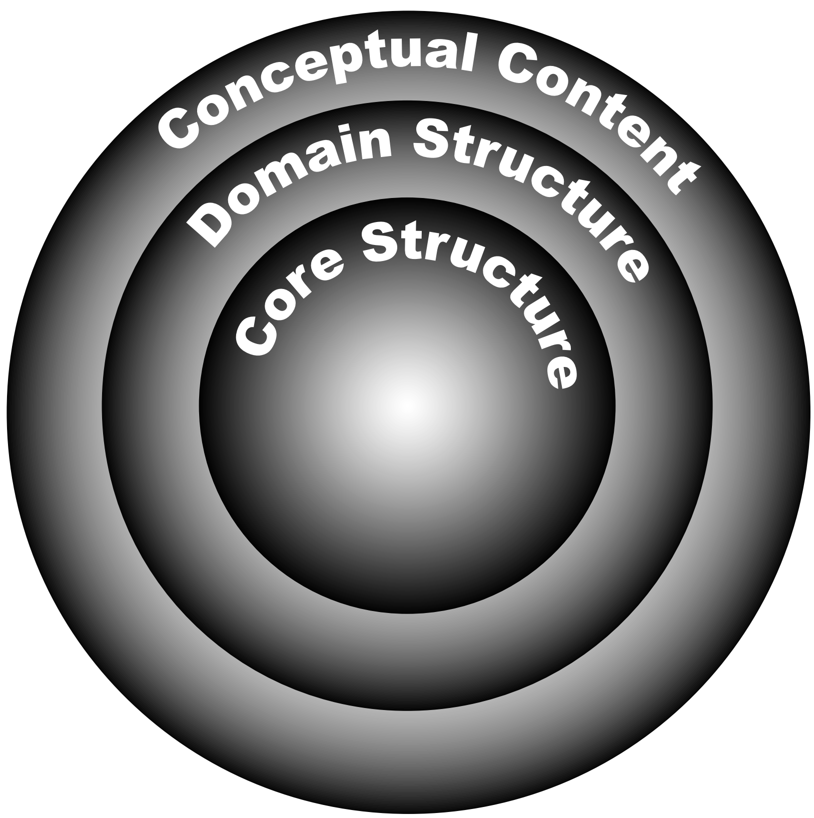

Table 1: Concepts identified in the energy literature

Investigators	Grade	Concepts identified										
		A Is a property of people, living things	B Is in fuel/ electricity/ food	C Is motion/ activity	D Is force or power	E Is a substance	F Causes things to happen	G Is created	H Comes in different forms	I Can be transferred	J Can be converted from one form to another	K Is conserved
Urevbu (1984)	3-6		X									
Nicholls & Ogborn (1993)	5	X	X	X		It can be lost/ used up	X					
Trumper (1993)	7-8	X	X	X	X	X	X	X				
Duit (1984)	7-10		X		X		X		mentioned	mentioned	mentioned	mentioned
Nicholls &	8	X	X			It can be				Energy is		

Investigators	Grade	Concepts identified										
		A Is a property of people, living things	**B** Is in fuel/ electricity/ food	**C** Is motion/ activity	**D** Is force or power	**E** Is a substance	**F** Causes things to happen	**G** Is created	**H** Comes in different forms	**I** Can be transferred	**J** Can be converted from one form to another	**K** Is conserved
Ogborn (1993)						lost/ used up				exchanged between objects		
Slotta, Chi, & Joram (1995)	9					X						
Shymansky, et al. (1997)	10				X	It can be lost/ used up			X			

Investigators	Grade	Concepts identified										
		A Is a property of people, living things	**B** Is in fuel/ electricity/ food	**C** Is motion/ activity	**D** Is force or power	**E** Is a substance	**F** Causes things to happen	**G** Is created	**H** Comes in different forms	**I** Can be transferred	**J** Can be converted from one form to another	**K** Is conserved
Hart (2002)	10		X		X							
Kesidou & Duit (1993)	10									Friction creates heat. No concept of transfer		
Harrison, Grayson, &	11							X	Heat	X	Heat	

Investigators	Grade	Concepts identified										
		A Is a property of people, living things	**B** Is in fuel/ electricity/ food	**C** Is motion/ activity	**D** Is force or power	**E** Is a substance	**F** Causes things to happen	**G** Is created	**H** Comes in different forms	**I** Can be transferred	**J** Can be converted from one form to another	**K** Is conserved
Treagust (1999)												
van Huis & van den Berg (1993)	11							Energy is work	Thermal energy	X	Mechanical, thermal, heat	
Goldring & Osborne (1994)	12				X	X				When energy is transferred, work is	Same as transfer	Energy is conserved in the laboratory

Investigators	Grade	Concepts identified										
		A Is a property of people, living things	**B** Is in fuel/ electricity/ food	**C** Is motion/ activity	**D** Is force or power	**E** Is a substance	**F** Causes things to happen	**G** Is created	**H** Comes in different forms	**I** Can be transferred	**J** Can be converted from one form to another	**K** Is conserved
										done.		only

Table 2: Distribution of interview sample by school grade at Time 1 and Time 2

	Time 1		Time 2	
Grade	**Frequency**	**Percent**	**Frequency**	**Percent**
0	2	2.1		
1	11	11.6		
2	5	5.3		
3	10	10.5		
4	5	5.3		
5	7	7.4		
6	1	1.1		
8	2	2.1		
9	50	52.6	41	93.2
10	0	0	3	6.8
11	2	2.1		
Total	95		44	

Table 3: Descriptions of 6 developmental levels

Level	Modal ages	Conceptual structure	Logical structure
Single representations	26-40 mos	**Concepts are 1st order representational sets** These coordinate sensori-motor systems. For example, the concept that television is bad for you coordinates activities like being told not to watch and not liking certain shows, whereas the concept that television is good for you coordinates activities like enjoying watching and being told some shows are good to watch.	**The logical structure is definitional** It identifies one aspect of a single representation—as in "T.V is fun," in which fun is an "aspect" of television.
Representational mappings	4-5 years	**Concepts are 2nd order representational sets** These coordinate or modify representational sets (the concepts	**The logical structure is linear** It coordinates one aspect of two or more representations—as in, "If

		constructed at the single representations level). The very popular representational mappings concept of *having favorites*, for example, can be employed to rank television shows. "Cartoons is my favorite to watch, and the Discovery Channel is my next favorite." Concepts like *being smart, changing one's mind*, and *not being allowed* also become common at this level. "I'm not allowed to watch T.V because it will make me dumb."	you watch T.V when you Mom says you can't she will get mad at you." Here, not doing what your mother says is coordinated with her anticipated reaction.
Representational systems	6-7 years	**Concepts are 3rd order representational sets** These coordinate elements of representational	**The logical structure is multivariate** It coordinates multiple aspects of two or more

		systems. For example, the concept of truth–rarely articulated before this level except as the opposite of a lie–can be used to describe a system of observations about television "It's true that T.V. is not good for you, because everybody thinks T.V is bad for your brain, so it must be true. But I still watch, when I'm allowed because it's fun."	representations—as in, "My Mom says watching T.V. is bad for me, but my Dad says that it is okay sometimes, so I don't know which is true. I hope my Dad, because I like T.V." In this example, two conflicting parental truth clams are coordinated by an admittance of uncertainty, and the statement of a personal desire.
Single abstractions	9-11 years	**Concepts are 1st order abstractions** These coordinate representational systems. For example, the concept that everyone has an opinion—rarely articulated before this level—defines collections of thoughts maintained over time. This	**The logical structure is definitional** It identifies one aspect of a single abstraction—as in, "People think what they want to think and other people think what they want to think, it's all opinion." in which individual opinions or preferred thoughts are

		notion is composed of qualities that produce different opinions, such as preferences and religious beliefs. "Everyone has their own opinion about television. You have to go by your own opinion."	defined as personal thoughts.
Abstract mappings	14-	**Concepts are 2nd order abstractions** These coordinate or modify abstractions. For example, the abstract mappings level conception of *proof* can be employed to coordinate elements to determine certainty. "In order to figure out whether television is bad for children, you have to look at the research. Does the research prove that children are harmed or	**The logical structure is linear** The most complex logical structure of this Lectical™ level coordinates one aspect of two or more abstractions—as in, "We'll probably never know whether television is good for kids because as soon as you prove something about it someone else can prove the opposite." Here, uncertainty about the status of the effects of T.V. is

		not?" Concepts like *coming to an agreement, getting more information,* and *accuracy*, and *facts* are also rare before this level. "Not everything everyone really believes is a fact, because their information could be inaccurate or they might not have enough information."	justified in terms of the uncertainty of proof.
Abstract systems	20-	**Concepts are 3rd order abstractions** These coordinate elements of abstract systems. For example, the abstract systems concept of *evaluating evidence* can coordinate information sources, agreement, certainty, validity, etc. "There is evidence on both sides of the question about	**The logical structure is multivariate** The most complex logical structure of this level coordinates multiple aspects of two or more abstractions. "Because there's a reasoning process behind our activities and your reasoning might be different than mind, I can't say there's always an absolute

		the impact of television on children. You either need to evaluate the validity of the evidence yourself or go with the evaluations of experts you have a reason to trust." Concepts like *multiple perspectives, relativism, ambiguity, bias,* and *validity* are also uncommon before the abstract systems level.	truth because you and I might both look at the same thing and even though I will articulate it and I feel beyond a shadow of a doubt that's how I saw it, you saw it differently." Here, the fact of indeterminacy, which is thought to result form differences in the reasoning process, is coordinated with the notion that absolute truth cannot be determined.

Table 4: Mean pre-instruction interview scores by school grade

	Time 1		Time 2	
Grade	**Mean**	**N**	**Mean**	**N**
0	7.00	2		
1	9.55	11		
2	11.00	5		
3	13.10	10		
4	15.20	5		
5	14.86	7		
6	20.00	1		
8	16.50	2		
9	18.61	50	18.07	41
10			16.11	3
11	23.17	2		

Table 5: Pre-instruction and post-instruction scores for students interviewed in both conditions

	Time 2							
Time 1	**Highly unelaborated SA**	**Unelaborated SA**	**Elaborated SA**	**Highly elaborated SA**	**Transition to AM**	**Highly unelaborated AM**	**Unelaborated AM**	**Elaborated AM**
Highly elaborated RS	1							
Highly unelaborated SA	1	1						
Unelaborated SA		1						
Elaborated SA					2			
Highly elaborated SA			1					
Transition to AM							2	
Highly unelaborated						1	1	

AM			
Unelaborated AM			1
Elaborated AM			1

Table 6: Pre-instruction and post-instruction scores for students filling out teasers in both conditions

	Time 2				
Time 1	**Elaborated RS**	**Unelaborated SA**	**Elaborated SA**	**Unelaborated AM**	**Elaborated AM**
Elaborated RS	3	6			
Unelaborated SA		41	15		
Elaborated SA		6	24	8	
Unelaborated AM			1	10	2
Elaborated AM				1	2

Table 7: Distribution of whole level scores for interviews at Time 1 and Time 2

Level	**Time 1**	**Time 1**
Representational mappings	11	
Representational systems	21	1
Single abstractions	41	32
Abstract mappings	22	11
Total	95	44

Table 8: Percentages of students performing at single abstractions at Time 1 and Time 2 expressing selected conceptions relating to energy

Number of students expressing concept at time 1	**Percentage of students expressing concept at time 1**	**Number of students expressing concept at time 2**	**Percentage of students expressing concept at time 2**	**Chi-square *df*=1**	**Concept**
28	**68.29**	4	12.50	22.72*	*States that gravity pulls/ pushes on the ball*
13	**31.71**	19	**59.38**	5.59*	*States that the energy of the ball decreases when it bounces*
16	**39.02**	19	**59.38**	2.98	*States that the energy of the ball increases during its fall*
15	**36.59**	25	**78.13**	12.52*	*Energy is associated with speed*
		10	**31.25**	14.85*	*States the speed of the ball is increased by the fall*
2	4.88	10	**31.25**	9.10*	*Mentions kinetic energy*
3	7.32	12	**37.50**	10.03*	General statement that

					gravity is related to energy
3	7.32	13	**40.63**	11.65*	*States that the energy of the ball can be transferred to the floor*
9	21.95	13	**40.63**	2.97	States that the energy of the ball increases as it speeds up
10	24.39	15	**46.88**	4.03*	*Describes energy in terms of force*
5	12.20	17	**53.13**	14.30*	*States that energy can be removed/lost*
5	12.20	18	**56.25**	16.16*	*States that energy is always present*

*$p < .05$

Table 9: Percentages of students performing at abstract mappings at Time 1 and Time 2 expressing selected conceptions relating to energy

Number of students expressing concept at time 1	**Percentage of students expressing concept at time 1**	**Number of students expressing concept at time 2**	**Percentage of students expressing concept at time 2**	**Chi-square *df*=1**	**Concept**
16	**72.73**	2	18.18	8.8*	*States that gravity pulls/ pushes on the ball*
8	**36.36**	3	27.27	0.27	*States that the energy of the ball decreases when it bounces*
8	**36.36**	4	**36.36**	0.0	States that the velocity/ speed of the ball is affected by gravity
8	**36.36**	4	**36.36**	0.0	*States that the energy of the ball increases during its fall*
9	**40.91**	4	**36.36**	0.06	States that the energy of the ball increases because of gravity
10	**45.45**	4	**36.36**	0.25	*States that the energy of*

					the ball can be transferred to the floor
9	**40.91**	5	**45.45**	0.06	States that the energy of the ball is decreased by friction
10	**45.45**	9	**81.82**	3.97*	*Mentions kinetic energy*
11	**50.00**	10	**90.91**	5.30*	Mentions potential energy
1	4.55	4	**36.36**	5.78*	*States that energy can be removed/ lost*
2	9.09	4	**36.36**	3.67*	Makes the general claim that energy is in everything
2	9.09	4	**36.36**	3.67*	Energy is associated with/defined in terms of work
3	13.64	4	**36.36**	2.27	States that some of the ball's energy is changed to potential energy
3	13.64	4	**36.36**	2.27	States that some of the ball's energy is changed to kinetic energy
5	22.73	4	**36.36**	0.69	States that energy can

					be transferred from one object to another
1	4.55	5	**45.45**	8.25*	States that some of the ball’s energy is changed to sound
2	9.09	5	**45.45**	5.80*	States that the energy of the ball changes as it bounces
0	0.00	5	**45.45**	11.79*	*States that the speed of the ball is increased by the fall*
2	9.09	5	**45.45**	5.80*	*Describes energy in terms of force*
2	9.09	6	**54.55**	8.25*	States that some of the ball's energy is changed to heat energy
1	4.55	6	**54.55**	10.97*	States that energy can be stored in an object
3	13.64	7	**63.64**	8.68*	Defines kinetic energy
3	13.64	8	**72.73**	11.52*	Defines potential energy
5	22.73	8	**72.73**	7.68*	States that friction slows the ball
4	18.18	8	**72.73***	9.43*	*Energy is associated*

					with speed
5	22.73	10	**90.91***	13.75*	*States that energy is always present*

*$p < .05$

Table 10: Post-instruction incidences of conceptions at single abstractions and abstract mappings

Number of students expressing concept at single abstractions	**Percentage of students expressing concept at single abstractions**	**Number of students expressing concept at abstract mappings**	**Percentage of students expressing concept at abstract mappings**	**Chi-square *df*=1**	**Concept**
12	**37.50**	3	27.27	0.38	General statement that gravity is related to energy
13	**40.63**	3	27.27	0.62	States that the energy of the ball increases as it speeds up
19	**59.38**	3	27.27	3.38	States that the energy of the ball is decreased by bounce
0	0	4	**36.36**	12.83*	States that some of the ball's energy is changed to potential energy
01	3.13	4	**36.36**	8.01*	States that some of

					the balls energy is changed to kinetic energy
02	6.25	4	**36.36**	8.81*	Energy is associated with/defined in terms of work
02	6.25	4	**36.36**	6.18*	General claim that energy is in everything
04	12.50	4	**36.36**	3.08*	States that energy can be transferred from one object to another
08	25.00	4	**36.36**	0.53	States that velocity/speed is affected by gravity
9	28.13	4	**36.36**	0.26	States that the energy of the ball increases because of gravity
3	9.38	5	**45.45**	7.04*	States that some of the ball's energy is changed to sound energy

3	9.38	5	**45.45**	7.04*	States that the energy of the ball changes
3	9.38	5	**45.45**	7.04*	States that the energy of the ball is decreased by friction
1	3.13	6	**54.55**	15.88*	States that some of the ball's energy is changed to heat energy
6	18.75	6	**54.55**	5.21*	States that energy can be stored in something
5	15.63	7	**63.64**		Defines kinetic energy
5	15.63	8	**72.73**		Defines potential energy
6	18.75	8	**72.73**		States that friction slows the ball
9	28.13	10	**90.91**		Mentions potential energy
13	**40.63**	4	**36.36**		States that energy can be transferred to the floor

17	**53.13**	4	**36.36**		States that energy can be removed/lost
19	**59.38**	4	**36.36**		States that the energy of the ball increases during its fall
10	**31.25**	5	**45.45**		States the speed of the ball is increased by the fall
15	**46.88**	5	**45.45**		Describes energy in terms of force
25	**78.13**	8	**72.73**		Energy is associated with speed
10	**31.25**	9	**81.82**		Mentions kinetic energy
18	**56.25**	10	**90.91**		States that energy is always there/present

*$p < .05$

Table 11: Reasoning about kinetic and potential energy—representational mappings to abstract mappings

Level	Description	Exemplars
Elaborated representational mappings	*Kinetic* and *potential energy* do not appear as meaningful concepts at this level. The only way the word energy is employed is to describe the physical energy of living things. Energy makes it possible for people to run and play. When children performing at this level are asked about the energy of a bouncing ball, they focus on its movement. In particular, they focus on it's *bounciness*. Bounciness makes it possible for balls to bounce.	[What will happen to the energy of the ball when you drop it?] The ball will hit the ground… and bounce all the way back up. [All the way back up. Oh.] Well, it will go down and then bounce straight to here… [Right there?] And then bounce down, and then bounce, bounce, bounce, until it goes littler. [Oh. Why does it do that, do you think?] I do not know. It's bouncy (Case 30043).
Elaborated representational systems	*Kinetic* and *potential energy* do not appear as meaningful concepts at this level. Children continue to focus on the physical movement of the ball, rarely	Explain what happens to the ball at the moment when it hits the floor.] It bounces up. [Yes. Why does it bounce?] There is air in the ball and it, and if it was flat it would

Level	Description	Exemplars
	employing the word energy in their descriptions. When the term energy is used, it clearly means movement. The composition of the ball is often mentioned as a factor in determining its bounciness.	just stay there or bounce a teeny bit and then fall. It bounces because it has been going down so fast it will come up. But it does not go up all the way to where it came from (Case 30025).
Elaborated single abstractions	*Kinetic* and *potential energy* are used as abstract concepts but without clearly elaborated relations to other concepts or each other. Kinetic energy is conceptualized as an energy of motion, while potential energy is conceptualized a potential for energy to happen. There no understanding of the ways kinetic and potential energy interact.	[A hand is pressing down on a ball that is sitting on top of a spring, does the ball have energy?] It is kinetic energy going into potential energy. [Okay so what is the kinetic?] The hand, it's pressing. [Okay and then when does it become potential?] When the spring is down, and then the spring pops up the ball to make it… Energy is, I guess,… movement. [So, what does potential energy mean to you?] Something that cannot move, or is not moving (Case 10380).

Level	Description	Exemplars
Elaborated abstract mappings	Descriptions of *kinetic* and *potential energy* are qualified by conceptions of their relations and the notion that there can be greater or lesser amounts of potential or kinetic energy—more of one means less of the other. They are typically related through mediating concepts of *energy transformation* and a partial understanding of *the law of conservation of energy*. Forms of potential energy, such as *gravitational potential energy* and *elastic potential energy* may be mentioned in more elaborated performances.	[When the ball is slowing down] it is gaining more potential, but it balances by losing kinetic. So, going down, speeding up, it gains more kinetic energy and loses potential, but it always keeps the same amount of energy, because of conservation of energy (Case 1641).

Table 12: Reasoning about energy transfer—representational mappings to abstract mappings

Level	Description	Exemplars
Elaborated representational mappings	*Energy transfer* does not appear as a concept at this level. Children performing at this level know that a ball will eventually stop bouncing, but they have no explanation for this phenomenon.	[Now, if I drop this ball…] It's gonna bounce back to you. [What happens to it as it's falling from…] It's dropping. [What do you think is happening to the energy of the ball…] It's falling. [And what happens after?] It bounces back up again. [Ok, let's see. You're right. But did you notice anything about the way it bounced?] Yeah. [What?] It went over and then down and over and then down. [Why do you think it keeps bouncing back up?] Because if you bounce it kind of up high, then it's still got some more bouncing to do (Case 20176).
Elaborated representational systems	*Energy transfer* does not appear as a meaningful concept at this level. Children performing at this level make detailed observations about the	[Alright, we have this ball. What is happening to the ball as it is falling?] It's dropping, getting faster, that's what makes the ball go higher but then when the ball bounces again, it keeps on getting lower and lower because the

Level	Description	Exemplars
	activity of a bouncing ball, almost universally observing that a it bounces lower and lower in a systematic way. They may link this loss of bounce to a loss of energy, where energy is equivalent to movement or speed.	energy is running out. [So, what happens to energy when it bounces?] The energy is like running out. When it bounces again, it then gets lower and lower and then stops. It loses energy. [So what is energy?] It is speed (Case 20180).
Elaborated single abstractions	A this level, *energy transfer* is the movement of energy, which is conceived as a substance, between objects via immediate contact or proximity.	[What happens to the energy of the ball at that moment when it hits the ground?] I think the energy will move into the ground, the force of the ball hits the ground and… it would hit the ground and then I guess the shock from it would just go into the ground (Case 30008).
Elaborated abstract mappings	The concept of *energy transfer* is used in conjunction with the notion of *energy forms* such as *heat* and *sound*. Energy	[Okay, so the reason that it is only going about half as high here is because some of the energy has been absorbed by the…?] It has been like transferred to the floor, and it gets transferred… [How is it

Level	Description	Exemplars
	transfer results from physical contact between objects.	transferred to the floor, do you know what the process is like?] It is when the ball comes in contact, it is like…the ball's energy turns into, it’s transferred into like sound and heat. It is kind of hard to explain (Case 10634). [After it bounces] the ball … will slow down. So, it will lose energy. Well, it’s not really lost, it is still there, but it is being transferred into heat and sound (Case 10530).

Table 13: Reasoning about the relation between gravity and energy—representational mappings to abstract mappings

Elaborated representational mappings	*Gravity* is conceived simply as being that thing that is responsible for pushing, pulling, or holding, things down. The concept is employed as a simple explanation for a ball's movement (falling).	Well, when I drop a ball it sort of starts to speed up. Oh! Because gravity is pulling it down. [How does gravity pull it down?] Because that is what gravity does. [Okay.] It pulls stuff down (Case 30023).
Elaborated representational systems	*Gravity* is conceived as a quasi-physical yet functional entity on par with other concretely describable aspects of a situation. Its function is to pull, push or hold things down, when the other aspects of the situation allow for this. Gravity is analogous to an invisible physical entity, such as wind or air, which is outside and separate from objects, and affects them in ways that are similar to the way they are affected by observable	It is harder for the ball to go up because gravity is pulling it down or something again, but, and it, even though it wants to go up. Kind of like if you climb a mountain, when you are going up it is a lot harder than when you are coming down, because you have to push against gravity. So, it is harder to make the ball go higher than having the ball come down because of gravity. [Okay.] So, it is going against gravity (Case 30065).

	entities. For example, people, horses, and gravity can push or pull.	
Elaborated single abstractions	*Gravity* is categorized as a force (or a type of energy). In some cases gravity is understood as a constant or general aspect of *all* situations, which functions differently under different concrete circumstances. For example, it slows a ball down on a flat surface or speeds a ball up going down a hill.	[So what is happening to the energy as it is making this first bounce?] It is decreasing. [And what is causing it to decrease?] The gravity. The ball wants to go back up. And the gravity pulls the ball to down. So, the energy… it is taking up more energy for the ball to get back up. So, when the ball finally stops, it's because the gravity pulls it down until all the energy is gone (Case, 10339).
Elaborated abstract mappings	*Gravity* is consistently and coherently employed in linear abstract explanations of situations. A variety of abstractions can be causally related and explicated relative to *gravity*, which is conceived as a constant force. When definitions	Gravity is a force pulling on it, so it will decrease its kinetic energy. Like if a ball is rolling along and gravity is pulling on the ball to slow it down, and as it starts slowing down, it will not have as much kinetic energy. And when it finally does stop it will have none.

	are offered, gravity is more clearly classed as a force and understood to be effective in relation to height, weight, etc.	That happens because of friction due to gravity (Case 10634).

Appedix C: Collaboration for Excellence in Science Education Research Paper

Dawson-Tunik, T. L., & Stein, Z. (in review). Developing conceptions of leadership.

Developing Conceptions of Good Leadership

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Abstract

Developing Conceptions of Leadership

A number of leadership theories emphasize the role of conceptions of leadership in leader/follower interactions and the concomitant need to understand what leaders and followers are thinking (Bass, 1985; Burns, 1978; Lord & Emrich, 2000). In an attempt to move toward a measure of leadership reasoning, we employed a research methodology called *developmental maieutics* to investigate the development of conceptions of leadership in a sample of children, adolescents, and adults. All respondents participated in open-ended clinical interviews designed to probe their conceptual understandings. The interviews were transcribed and submitted to two independent analyses. First, interviews were scored with a general developmental assessment system, the Lectical™ Assessment System (Dawson-Tunik, 2005). Next, the interviews were submitted to a detailed analysis of their conceptual content. The combined results were employed to construct an account of the development of leadership conceptions.

Key words: developmental stages, hierarchical complexity, conceptual development, leadership, evaluative reasoning

Developing Conceptions of Leadership

A number of leadership theories emphasize the role of conceptions of leadership in leader/follower interactions and the concomitant need to understand what leaders and followers are thinking in order to actively promote high quality leader/follower relationships (Bass, 1985; Burns, 1978; Lord & Emrich, 2000). In an attempt to move toward a measure of leadership reasoning, we employed the methods of *developmental maieutics* to investigate the development of leadership conceptions in a sample of 190, 5- to 85-year-olds. We begin with a review of the literature on leadership conceptions and a description of our perspective on conceptual development.

Conceptions of leadership

Implicit leadership theories

Much of the literature on leadership conceptions focuses on cognitive structures called implicit leadership theories (ILTs). ILTs are mental constructs that can be thought of as hierarchical taxonomies of leader qualities called prototypes (Rosch, 1978). These serve to simplify the environment by acting as filters for information about actual leaders, and are thought to be influential in a number of leader/follower behaviors. In their review of the information processing research in this area Lord and Emrich (2000) summarize 13 main points of agreement. Several of these points implicate the ILTs constructed by leaders and their followers. The three that are most directly relevant to the content of this article are as follows:

1. The effects of the social system on leader behavior are mediated by the leader's metacognitive processes, and perceptions of the leader are mediated by the follower's metacognitive processes.

2. The most immediate determinant of perceptions of a leader is the activation of a perceiver's implicit leadership theory (ILT), whereas the most immediate determinant of a leader's behavior is the leader's ILT.
3. The context sensitivity of perceivers' and leaders' metacognitive processes lies in their ability to activate appropriate ILTs.

One direct implication of these propositions is that in order to predict the behavior of leaders or followers, we need to know something about their metacognitive processes and their conceptions of leadership (ILTs). A second, perhaps less obvious, implication is that if we wish to promote the development of leaders' and followers' metacognitive processes and leadership conceptions, we need to understand something about the ways in which they typically develop.

In research on ILTs, leader qualities are grouped into categories, often through an analysis of the factor structure of a sample of survey responses. In one approach, respondents, who are provided with limited information about a hypothetical leader, are then asked to rate the behavior of that leader on a number of dimensions. Eden and Leviatan (1975) employed this procedure with a sample of Israeli students, who responded to the questions on leader behavior in the Survey of Organizations (Taylor & Bowers, 1972). A factor analysis revealed four factors—*support*, *work facilitation*, *interaction facilitation*, and *goal emphasis*. In an almost identical study of American students, Weiss and Adler (1981) identified the same four factors.

In a similarly designed study using the Ohio State Leader Behavior Description Questionnaire (Stodgill, 1963), Rush, Thomas, and Lord (1977) asked American undergraduates to assess the behavior of a leader about whom they had received minimal information. The result was a two factor structure—*consideration* and *initiating structure*.

These same factors were identified in Schriesheim and Stogdill's (1975) research on university employees.

In a later study with a different design, Offerman, Kennedy, and Wirtz (1994) investigated the ILTs of college students. Offerman and his colleagues asked 686 undergraduates to rate the importance of 160 qualities identified as qualities of leaders by a separate group of undergraduates. A factor analysis of their responses revealed eight factors that distinguish ILTs, including *sensitivity*, *dedication*, *tyranny*, *charisma*, *attractiveness*, *masculinity*, *intelligence*, and *strength*.

There is wide agreement that ILTs are likely to vary cross-culturally and contextually (Keller, 1999; Offermann et al., 1994), and the evidence that is available lends some support to this hypothesis. Studies of British (Bryman, 1987), Chinese (Ling, Chia, & Fang, 2000), Israeli (Eden & Leviatan, 1975), and Arabic (Abdalla & Al-Homoud, 2001) samples reveal somewhat different factor structures than those identified in American studies. In some cases, these are striking. For example, in their study of a Chinese sample, Ling, Chia, & Fang identified 4 factors: *goal efficiency*, *interpersonal competence*, *versatility, and personal morality*. Somewhat surprisingly, personal morality did not emerge as a factor in American studies. In other cases, variations are more subtle. Bryman (1987), for example, reports a factor structure that is almost identical to those reported by Schriesheim and Stogdill (1975) and Rush, Thomas, and Lord (1977).

A brief consideration of the abovementioned studies does not provide a coherent picture of ILTs. The factors identified by these researchers certainly have face validity, in that we can agree that most of them are qualities of leaders or leadership, but the factor structures revealed in different studies vary widely according to the instrument used to assess beliefs.

Whereas interpersonal skills and goal attainment skills figure in every study, there are some traits, such as masculinity, intelligence, strength, versatility, and personal morality, that appear as factors in some studies but not others. If all we can agree upon is that people think that interpersonal skills and goal attainment skills are important to leadership, we have not learned very much about leadership conceptions. Thus, although ILTs are considered to be important in leader/follower behavior, there is, as yet, no agreement upon the specific structure of ILTs. This severely limits the practical value of the construct.

Developmental perspectives

Weiss and Adler (1981) reported that subjects' cognitive complexity did not affect their descriptions of the imaginary leader, but other researchers have described developmental differences in leadership conceptions that reflect increasing differentiation and integration of cognitive structures. Selman & Jaquette (1977), for example, proposed 5 developmental stages of reasoning about leadership. Within this scheme, the first level, stage 0—*physicalistic connections*—leadership is viewed as physical power over others. A leader tells others what to do and they are supposed to do it. At stage 1—*unilateral relations*—leaders are seen as being the ones who are best skilled and know the most, and leadership is seen as a unilateral and authoritarian. At stage 2—*bilateral partnerships*—leadership is viewed from the perspectives of both leader and followers. Leadership is based on equality and reciprocity. A good leader can coordinate different claims, allowing the group to move beyond the conflicting interests of individual members. At stage 3—*homogeneous community*—the role of the leader is seen as the ability to establish solidarity within the group, which is viewed as a social system. A good leader reflects the concerns of the group itself, rather than imposing his or her own will. At stage 4—*pluralistic organization*—leadership is viewed as one of several social role responsibilities that promote the collective good of the group. The leader fills a position created by the organizational demands of complex organizations.

A decade later, Daniels-Beirness (1986) examined the responses of 160 five- to twelve-year-old children to a series of leadership dilemmas. She classified responses into 9 categories. Two of these—*global positive evaluations* and *superior knowledge*—were identified in every age group. One category—*concrete external (overt) characteristics*—was observed more often in the performances younger respondents. And finally, six attributes—*resourcefulness, initiative, getting along with others, being concerned with the welfare of others, the ability to command respect*, and *integrity*—increased with age. Daniels-Bearness concluded that the development of leadership proceeds from a focus on the concrete physical characteristics of leaders to affective/interpersonal aspects of leadership. We would add that the categories found at every level—*global positive evaluations* and *superior knowledge*—can be thought of as thematic categories that are fundamental to the leadership construct. This point will be discussed further below.

Matthews, Lord, and Walker (1988) identified a similar trend when they examined the development of leadership perceptions in 159, 1st, 3rd, 6th, 9th, and 12th graders. They reported that, compared to the younger students, older students spoke more about roles of leaders rather than specific actions , focused on general rather than specific qualities, described more features of leaders, and talked about prototypes rather than particular exemplars.

The transformational leadership model (Bass, 1985; Burns, 1978) is a developmental model of leadership featuring two qualitatively different types of leadership—*transactional* and *transformational*. Transactional leaders engage in an exchange with followers in which leaders give followers something they want in exchange for something wanted by the leader.

Transformational leaders, on the other hand, are able to unite followers around shared values, beliefs, and goals. Leader cognitions are thought to be directly related to leadership style. For example, Wofford and Goodwin (1994) argue that the schemata and scripts of leaders predict leadership behaviors. They further argue that the content of these schemata and scripts are different for transactional and transformational leaders. Transactional leaders, for example, expect followers to exhibit commitment to goals, expect rewards, and require clarity about roles (House & Dressler, 1974), whereas transformational leaders may expect followers to exhibit self-reliance, creativity, and initiative (Bass, 1985; Conger & Kanungo, 1987; House, 1977). Kuhnert and his colleagues (Kuhnert & P., 1987; Lewis, Kuhnert, & Maginnis, 1987) propose a three stage constructive/developmental progression from transactional to transformational leadership that is strongly influenced by Kegan's (1982) model of ego development. They call these stages *imperial* (lower-order transactional), *interpersonal* (higher-order transactional), and *institutional* (transformational). Kuhnert and Lewis (1987) argue that, if this model is to become useful, it is necessary first to provide a detailed account of the development of reasoning about leadership, and then to develop measures that can provide accurate estimates of the developmental level of reasoning employed by leaders and their followers. It is our purpose to begin this process.

Developmental maieutics

Developmental maieutics is a methodology designed to connect developmental research to curricula and assessment through cycles of research and application. Figure 1 portrays a framework for the cycles of research and application that are a part of this approach. We have chosen the spiral to represent these cycles, because we employ an iterative process in which what is learned during one cycle informs the direction of the following cycle. The small sub-cycle to the right represents an application of the research design employed in the study described in this article. Over the course of time, this sub-cycle would be repeated several times, not only to clarify the pathways through which individuals attain concepts, but to identify and classify the skills and knowledge that comprise a given domain of knowledge.

-------------------------insert Figure 1 about here-------------------------

The research cycle represented in Figure 1 (small spiral on the right of the figure) involves submitting interview data to multiple forms of qualitative analysis. First, interview or essay texts are separately analyzed for their (1) developmental level, (2) conceptual content, and sometimes (3) their lexical composition. Then, the results of these analyses are brought together and examined to identify trends in conceptual development. To conduct the developmental analysis, we evaluate the hierarchical structure (or skill level, see Fischer, 1980) of reasoning performances with the Lectical™ Assessment System (LAS) (Dawson-Tunik, 2005) which primarily is based upon Fischer's skill theory (1980) and Commons' Model of Hierarchical Complexity (Commons, Trudeau, Stein, Richards, & Krause, 1998). To conduct the content analysis we attend to the specific meanings expressed in the same performances (Dawson-Tunik, 2004; Dawson-Tunik & Stein, submitted). Likewise, a variety of lexical analyses can be employed to examine patterns of lexical composition (Dawson & Wilson, 2004). With this method, Dawson-Tunik and her colleagues have described developmental sequences for conceptions of energy, good education, epistemology, learning, morality, and the self, and for critical thinking, decision-making, and problem-solving (Dawson, 2004; Dawson & Gabrielian, 2003; Dawson & Stein, 2004; Dawson-Tunik, 2004; Dawson-Tunik & Stein, 2004a; Dawson-Tunik & Stein, 2004b; Dawson-Tunik & Stein, in review).

Hierarchical development

Developmental levels, also referred to here as *orders of hierarchical complexity* or *complexity levels,* are conceived of as a series of hierarchical integrations of knowledge structures. Many developmental theories employ the notion of hierarchical complexity. In the Piagetian model, for example, each successive hierarchical integration produces novel understandings by employing the operations of the previous order as conceptual elements in its new constructions. This notion is central to several other developmental theories as well, including those of Werner (1948), Case (1985), and Fischer (1980), and underlies a number of developmental scales, such as the levels and tiers of Fischer's (1980) skill theory and the complexity orders of Commons' General Stage Model (Commons et al., 1998).

The Lectical™ Assessment System (LAS)

Several attempts have been made to develop a generalized developmental assessment system for human raters. Indeed, Piaget defined each of his developmental stages in generalized terms. Conservation, for example, is a general feature of concrete operations and can be observed on a wide range of tasks. Case (Case, Griffin, McKeough, & Okamoto, 1992), Fischer (Fischer & Bidell, 1998; Rose & Fischer, 1989), and their colleagues have employed generalized definitions to scale performances across domains, but have not disseminated generalized scoring systems. Based primarily on Commons' General Stage Scoring System (Commons, Danaher, Miller, & Dawson, 2000) and Fischer's skill theory (1980), the LAS (Dawson-Tunik, 2005), employed here, lays out explicit general criteria for determining the developmental level of performances in any domain of knowledge.

The thirteen skill levels described by Fischer and his colleagues (Fischer & Bidell, 1998) and the first 13 of Commons' 15 stages are defined similarly. We employ the level names from Fischer's skill theory to label our complexity levels. These are (0) reflexive actions, (1) reflexive mappings, (2) reflexive systems, (3) single sensorimotor actions, (4) sensorimotor mappings, (5) sensorimotor systems, (6) single representations, (7) representational mappings, (8) representational systems, (9) single abstractions, (10) abstract mappings, (11) abstract systems, and (12) single principles/axioms.

When assessing the hierarchical complexity of a text with the LAS, the rater attends to two manifestations of hierarchical complexity. The first is its conceptual structure, embodied in the *hierarchical order of abstraction*[i] of the new concepts employed in its arguments, and the second is the most complex *logical structure* of its arguments. Note that conceptual and logical structures are definitionally identical and fundamentally interdependent. We make a distinction between the two types of structure for heuristic and pragmatic reasons. When scoring texts, hierarchical order of abstraction refers primarily to the structure of the elements of arguments, which often must be *inferred* from their meaning in context, whereas logical structure refers to the *explicit* way in which these elements are coordinated in a given text.

Each complexity order is associated with a hierarchical order of abstraction (reflexive actions, sensorimotor schemes, representations, abstractions, or principles) and one of 3 logical forms (elements, mappings or relations, and systems. For a more complete account of the scoring system, see the methods section and the LAS web site (Dawson-Tunik, 2005).

Reliability and validity of the scoring system

We have undertaken several studies of the reliability and validity of the LAS and its predecessors (Dawson, 2002, 2003, 2004; Dawson & Gabrielian, 2003; Dawson, Xie, & Wilson, 2003; Dawson-Tunik, 2004). We have examined inter-analyst agreement rates, compared scores obtained with the LAS with scores obtained with more conventional scoring systems, and examined the functioning of the scale through statistical modeling. Inter-analyst agreement rates have been high, 80% to 97% within half of a complexity level (Dawson, 2004; Dawson & Gabrielian, 2003; Dawson-Tunik, 2004)[ii]. Correspondences between other developmental scoring systems and the LAS are also high, consistently revealing agreement rates of 85% or greater within ½ of a complexity level (Dawson, 2002, 2004; Dawson et al., 2003). Employing Rasch scaling, which provides reliability estimates that are equivalent to Cronbach's alpha, we have consistently calculated reliabilities over .95 (Dawson, 2002; Dawson et al., 2003; Dawson-Tunik, 2004). Overall, our research shows that the LAS is a valid and reliable general measure of intellectual development from early childhood through adulthood.

Method

Sample

In order to describe a sequence of conceptual development, it is necessary to sample a wide age-range, preferably extending to the youngest age group that can reasonably complete a given task. In part, this is because it is impossible to determine the developmental level at which concepts are first demonstrated without sampling down to a developmental level at which the concepts have not yet appeared. Consequently, although our target group was adult government managers, we also interviewed a group of children and adolescents. The age range was 5–75. The sample distribution is shown in Table 1.

-------------------------insert Table 1 about here-------------------------

Instrument

We conducted open-ended clinical interviews, guided by the question, "What is a good leader?" We employed a clinical interview method, adapted by Armon (1984) from an approach developed by Piaget (1929) and Kohlberg (1969). Questions and probes were chosen to encourage participants to expand upon their conceptions of good leadership and elicit their highest level of reasoning. Responses were probed with requests for further elaboration—"Why is that good?" "Why is that important?" "Why should good leadership include both of those things?"—until the interviewer was satisfied that a given participant had presented as full an account as possible of his or her reasoning. The interviewer did not introduce concepts of her own. Instead, she noted the elements of good leadership mentioned by the participant and probed for explanations of why these are important. The interviews varied in length from 10 to 45 minutes.

Developmental analysis

To assess the developmental level of the interviews for this study, we employed the Lectical™ Assessment System (LAS). The LAS is based on a three-layer model of conceptual structure. In this model, the outer layer represents *conceptual content*, the middle layer represents *domain-level structure*, and the inner layer represents *core* structure. The LAS targets the inner layer—core structures—to determine the *complexity level* of a performance. These core structures are *hierarchical order of abstraction* and *logical structure*. Appendix A provides short definitions of each of the levels identified in the sample of interviews collected for this project, along with commonly reported modal ages of acquisition. See the LAS web site (Dawson-Tunik, 2005) for more information about these constructs and examples of performances from each level in several knowledge domains.

Most other scoring systems target domain-level structures such as *sociomoral perspective* (in the moral domain) and form of relativism (in the epistemological domain). Many of these scoring systems also target conceptual content. Moreover, most domain-specific scoring manuals are based on the conceptualizations of a small sample of respondents and are extremely expensive and time consuming to produce. This limits their generality and availability. The main advantage of these systems is that it is much easier to score using a system based on domain structure and conceptual content than it is to score with a system that focuses on the much more abstract concepts of hierarchical order of abstraction and logical structure. The former primarily involves matching the arguments made by a respondent with exemplars in a scoring manual. The latter involves an examination of the deep structures implicated in the meanings conveyed by a given text. It is not possible adequately to describe our scoring procedures in the methods section of a paper. It takes many hours of instruction and practice to become an accurate LAS analyst. Given this caveat, we offer the following brief overview of the assessment system.

To assign a score based on hierarchical order of abstraction and logical structure, LAS analysts must understand how these manifest in a given performance. Scoring is an iterative process; the analyst alternately examines each layer of structure until he or she converges on an interpretation of the core structure of the performance. For example, an analyst was asked to score the following interview segment:

> [*Could you have a good life without having had a good education?*] Yeah, probably so, I would say. I wouldn't...it would be richer with education, but it wouldn't... [*Why do you think it would be richer with education?*] Well, you just, your mind would be open to a lot more things (case 0212).

The analyst's response illustrates how each layer of structure plays a role in the scoring process:

> Well, this isn't a very sophisticated notion of the role of education in the good life. Especially because, at first, I thought that he was saying that you'd be richer,

> money-wise (laughter), with an education. That would make 'richer' a [representational] notion, but I see that it's actually at least abstract, because it's related to this idea of open-mindedness. It seems there are two variables [richer life, open mind] that are in a logical relation to one another…as in, "If you get a good education, your mind will be more open, and therefore you will have a richer life." This would make it at least [abstract mappings], but could it be higher than that? Well, *richer life* could be higher than [single abstractions], and so could *open mind*, so I'm looking for evidence that they are…but the perspective here is of the individual person and his life, without bringing in anyone else's perspective, or a social perspective, so you can't say, really. [Abstract mappings]; I'll stick with that.

In this example, the analyst appeals to all three levels of structure. The content level is referenced in her initial attempt to understand the argument, and again when she double checks her understanding at the end. The domain structure level is briefly included when she examines the social perspective of the respondent to see if there are grounds for considering the possibility that the statement is at a higher level than abstract mappings. The core structure is reflected in her analysis of the hierarchical order of abstraction and logical structure of the argument.

From this example, it is clear how *meaning* is central to the scoring process. Without a correct interpretation of the meaning of a statement, the analyst cannot even begin the process of scoring. In this case, knowing which sense of *richer* is intended by the respondent is essential to a correct interpretation of the hierarchical order of abstraction of the concept.

LAS analysts are required to maintain an agreement rate of 85% within 1/3 of a complexity level with a Certified Master LAS analyst.

Each leadership interview was assigned a single complexity phase score, as follows: unelaborated representational mappings (URM), elaborated representational mappings, (ERM) transition to representational systems (TRS), unelaborated representational systems (URS), elaborated representational systems (ERS), transition to single abstractions (TSA), unelaborated single abstractions (USA), elaborated single abstractions (ESA), transition to abstract mappings (TAM), unelaborated abstract mappings (UAM), elaborated abstract mappings (EAM), transition to abstract systems (TAS), unelaborated abstract systems (UAS), elaborated abstract systems (EAS), transition to single principles (TSP), unelaborated single principles (USP), and elaborated single principles (ESP). The distribution of complexity levels is shown in Table 2.

-------------------------insert Table 2 about here-------------------------

Content analysis

The interviews were coded for their conceptual content by two trained undergraduate student coders. The coders were provided with a lengthy list of themes and concepts that had been developed by the first author following an initial analysis of the content of a representative sub-sample of the interviews. The coder was instructed to code every relevant theme and associated concept(s) in each interview, preferably assigning themes and codes from the original list. In cases where there was no existing code that closely represented the meaning being conveyed by a respondent, the coder suggested the creation of a new code. New codes were incorporated subject to the agreement of the first author, who also assessed the consistency of coding at frequent intervals throughout the coding process. Coders were occasionally asked to change or add coding categories following these assessments. In the end, there were 8 themes and 449 concept codes (The number of concept codes under each theme is shown in brackets to the right of each theme name.)—affect (24), cognition (57), communication (49), ethics (40), personality (41), social skills (87), skill (other) (59), and style (92). The coding scheme allowed for a high degree of specificity. For example, there were separate codes for the notions that “a good leader speaks well” and “a good leader is a good communicator”. By preserving fine distinctions in meaning, we optimized our ability to detect sometimes subtle changes in meaning from on complexity level to the next.

The first step in the concept analysis was to order concept codes by the developmental levels at which they first occurred in performances. Table 3 portrays the distribution of codes under the ethics theme. This distribution of codes is the starting point in our analysis. This information is employed to scaffold a qualitative analysis of developmental differences, in which we move back and forth between the information in tables of this kind and the original interviews, gradually constructing an account of the developmental pathways revealed in a given set of interviews.

-------------------------insert Table 3 and Figure 1 about here-------------------------

Results

Developmental analysis

<u>Core structure:</u> Scores on the good leadership interviews were distributed by educational level as shown in Figure 2. In this figure, educational attainment is shown on the x axis, and complexity scores are represented on the y axis. A dotted vertical line represents the range of complexity scores for the associated educational level, a solid line represents the confidence interval around the mean complexity level, the numbers below the dotted lines represent the number of individuals in each educational level, and a box or circle represents the mean. Each mean that is represented with a circle marks a developmental milestone, as follows: The mean and confidence

interval for 0 completed years of education lie within the representational mappings (RM) range, the mean and confidence interval for 1 completed year of education lie within the representational systems (RS) range, the mean and confidence interval for 5 completed years of education lie within the single abstractions (SA) range, and the mean and confidence interval for 17 years of education lie within the abstract systems (AS) range. Abstract mappings (AM) and single principles (SP) are not similarly represented here, though the mean for respondents who have completed 21 years of education is within the single principles range. Abstract mappings generally predominates after 10 completed years of education, and single principles rarely predominates before the completion of a Ph.D.

--------------------------insert Figure 2 about here--------------------------

Note that the ranges around the means in Figure 2 generally are somewhere between one and two complexity levels. This is the case at every developmental level. We should not lose sight of these variations. They represent a fundamental truth about development—human beings develop at different rates. Because individuals performing at different developmental levels learn and think differently, this has enormous implications for educational programs.

<u>Domain structure:</u> Figure 3 describes the domain structures for evaluative reasoning about good leadership for 7 complexity levels from single representations to single principles. The first conception of a leader that emerges (at single representations) is that a leader is the one who goes first. The child performing at this level literally places the leader at the front of a queue, be it the lunch-line, the line waiting for a turn at the bat, or the person one must follow, as in the game, *follow-the-leader*. At the representational mappings level, the simple, yet fundamental, notion that leaders go first is elaborated and extended by the idea that a good leader has certain concrete responsibilities (jobs to do). For example, a good leader in follow-the-leader does a lot of

jumping around, a good room leader raises his finger to tell other students when it is time to be quiet, or a good scout leader takes you on camping trips. At representational systems, leaders are described as individuals who are in charge of other people and whose responsibilities (things they should do or ways they should act) are different depending upon the specific situation and those involved in it. For example, children performing at this level may argue that being brave is good if you are leading soldiers because then they will be brave too.

--------------------------insert Figure 3 about here--------------------------

At single abstractions, earlier observations of leaders in a variety of contexts are coordinated to construct a generalized conception of good leaders as good persons—those who do what is right or what should be done. This conception of leaders integrates and subsumes the traits or skills of the representational tier, including being honest, fair, kind, brave, or knowledgeable. At abstract mappings good leaders are conceptualized as having a variety of abstract qualities or capabilities that can be applied in real world situations. The good leader is more than a good person, he or she must possess all of the qualities or capabilities required for leading. At abstract systems, the good leader is one who not only possesses and applies the appropriate qualities and capabilities, he or she must also be able to apply these flexibly in a variety of contexts. Particular qualities and capabilities are no longer simply positive or negative—they are relative to contexts. Sensitivity to context is stressed.

Finally, at single principles, the good leader is viewed as an individual who maintains his or her integrity as an autonomous principled agent in a variety of contexts. This capacity integrates and subsumes the lists of traits, qualities and capabilities constructed in the abstract tier. Leaders orient their actions around highly abstract principles that can be employed to coordinate multiple perspectives. This coordination of perspectives makes it possible to integrate the demands of different contexts within a common framework. Such a framework, because it emerges from the evaluation of local norms in light of universalizable normative processes and guidelines, may transcend current standards.

Surface structure: Figure 4 shows the thematic structure of the leadership domain. Prior to abstract mappings, three broad precursor themes were apparent in performances. These were goodness, niceness, and smartness. Note the similarity of these general themes to those identified by (Daniels-Beirness, 1987)—global positive evaluations and superior knowledge. The main difference between the themes we identified and those identified by Daniels-Bearness is that we found that even young children differentiated between goodness and niceness, allowing us to break down the category, *global positive evaluations*, into two more specific themes.

From abstract mappings onward, we identified 8 themes, including ethics, social skills, emotion, personality, style, communication, skills (other) and cognition. The conceptual relations between the precursor themes and these more differentiated themes are indicated with connecting lines. For the most part, the list of factors/traits identified by ILT researchers are either similar to one of these themes—*interaction facilitation* (Eden & Leviatan, 1975; Weiss & Adler, 1981), *intelligence* (Offermann et al., 1994), *interpersonal competence and personal morality* (Ling et al., 2000)—or can be subsumed under one of these themes—*support*, *work facilitation*, *goal emphasis* (Eden & Leviatan, 1975; Weiss & Adler, 1981), *sensitivity*, *dedication*, *tyranny*, *charisma*, *strength* (Offermann et al., 1994), *goal efficiency* and *versatility* (Ling et al., 2000). The only traits in this list that were not often identified in our sample were *attractiveness* and *masculinity* (Offermann et al., 1994). Figure 5 illustrates our understanding of these relations. ILT factors/traits are shown in italics.

-------------------------insert Figures 4 & 5 about here-------------------------

Table 4 provides descriptions of the conceptual content identified on the thematic strands observed at representational mappings, representational systems, and single abstractions. The surface structure (conceptual content) of any domain is more difficult to summarize than its core or domain structures, particularly after the single abstractions level, when themes become more differentiated and concepts become more nuanced. Consequently, we must confine ourselves to reporting only a portion of our findings for abstract mappings through single principles[iii]. Table 5, presents the conceptual sequence observed on 3 out of 8 thematic strands, each of which is related to at least one of the precursor themes identified at the lower complexity levels. These are ethics (goodness), style (niceness), and cognition (smartness).

-------------------------insert Tables 4 & 5 about here-------------------------

Discussion

The results of this study provide a clear response to the call for a better understanding of leadership conceptions. The methods of *developmental maieutics* have allowed us to identify the conceptual themes that are central to this construct and to provide an account of the ways in which these themes develop over the course of development. The results augment existing accounts of leadership conceptions, providing a more nuanced account of their development, structure, and content.

An understanding of the typical pathways through which leadership conceptions develop provides a solid basis for the design of accurate and reliable assessments of leadership reasoning. The next step is to develop and test such an assessment. We have established the basis for (and begun the development of) an on-line assessment of reasoning about leadership that coordinates sub-assessments of hierarchical complexity and conceptual content (Dawson & Wilson, 2004). This assessment will be employed in future research on the development of leadership conceptions as well as investigations of its value in real-world contexts.

The sample collected for this project is far from representative, and our results should therefore be interpreted with some caution. We regard this project as a first step in describing the development of leadership conceptions. Future work will include more diverse samples, more longitudinal evidence, and experimentation with different types of learning interventions. We anticipate identifying additional conceptions as well as a number of differences in emphasis (or conceptual bias) in different samples. Despite the limitations of the sample, the evidence presented here demonstrates the value of a methodology that incorporates a general measure of cognitive development, provides evidence for a general sequence in the development of leadership conceptions, and expands our understanding of the thematic structure and conceptual content of the domain.

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Appendix A

Descriptions of 6 developmental levels

Level	**Modal ages**	**Conceptual structure**	**Logical structure**
Representational mappings	4-5 years	**Concepts are 2nd order representational sets** These coordinate or modify representational sets (the concepts constructed at the single representations level). The very popular representational mappings concept of *having favorites*, for example, can be employed to rank television shows. "Cartoons is my favorite to watch, and the Discovery Channel is my next favorite." Concepts like *being smart, changing*	**The logical structure is linear** It coordinates one aspect of two or more representations—as in, "If you watch T.V when you Mom says you can't she will get mad at you." Here, not doing what your mother says is coordinated with her anticipated reaction.

		one's mind, and *not being allowed* also become common at this level. "I'm not allowed to watch T.V because it will make me dumb."	
Representational systems	6-7 years	**Concepts are 3rd order representational sets** These coordinate elements of representational systems. For example, the concept of truth–rarely articulated before this level except as the opposite of a lie–can be used to describe a system of observations about television "It's true that T.V. is not good for you, because everybody thinks T.V is bad for your brain, so it must be true. But I still watch, when I'm	**The logical structure is multivariate** It coordinates multiple aspects of two or more representations—as in, "My Mom says watching T.V. is bad for me, but my Dad says that it is okay sometimes, so I don't know which is true. I hope my Dad, because I like T.V." In this example, two conflicting parental truth clams are coordinated by an admittance of uncertainty, and the statement of a personal desire.

		allowed because it's fun."	
Single abstractions	9-11 years	**Concepts are 1st order abstractions** These coordinate representational systems. For example, the concept that everyone has an opinion—rarely articulated before this level—defines collections of thoughts maintained over time. This notion is composed of qualities that produce different opinions, such as preferences and religious beliefs. "Everyone has their own opinion about television. You have to go by your own opinion."	**The logical structure is definitional** It identifies one aspect of a single abstraction—as in, "People think what they want to think and other people think what they want to think, it's all opinion." in which individual opinions or preferred thoughts are defined as personal thoughts.
Abstract mappings	14-	**Concepts are 2nd order abstractions** These coordinate or	**The logical structure is linear** The most complex logical

		modify abstractions. For example, the abstract mappings level conception of *proof* can be employed to coordinate elements to determine certainty. "In order to figure out whether television is bad for children, you have to look at the research. Does the research prove that children are harmed or not?" Concepts like *coming to an agreement, getting more information,* and *accuracy*, and *facts* are also rare before this level. "Not everything everyone really believes is a fact, because their information could be inaccurate or they might not have enough	structure of this Lectical™ level coordinates one aspect of two or more abstractions—as in, "We'll probably never know whether television is good for kids because as soon as you prove something about it someone else can prove the opposite." Here, uncertainty about the status of the effects of T.V. is justified in terms of the uncertainty of proof.

		information."	
Abstract systems	20+	**Concepts are 3rd order abstractions** These coordinate elements of abstract systems. For example, the abstract systems concept of *evaluating evidence* can coordinate information sources, agreement, certainty, validity, etc. "There is evidence on both sides of the question about the impact of television on children. You either need to evaluate the validity of the evidence yourself or go with the evaluations of experts you have a reason to trust." Concepts like *multiple perspectives, relativism, ambiguity, bias,*	**The logical structure is multivariate** The most complex logical structure of this level coordinates multiple aspects of two or more abstractions. "Because there's a reasoning process behind our activities and your reasoning might be different than mind, I can't say there's always an absolute truth because you and I might both look at the same thing and even though I will articulate it and I feel beyond a shadow of a doubt that's how I saw it, you saw it differently." Here, the fact of indeterminacy, which is thought to result form

		and *validity* are also uncommon before the abstract systems level.	differences in the reasoning process, is coordinated with the notion that absolute truth cannot be determined.
Single principles	26+	**First order axioms** At this level, the new concepts are referred to as first order principles. These coordinate abstract systems. Concepts like *web of existing knowledge*, *interrelating truths to extract a single truth*, and *coordinating principle* are not constructed before this level.	**Definitional** The most complex logical structure of this level identifies one aspect of a principle or axiom coordinating systems, as in "Knowledge, viewed from a variety of perspectives can inform the structuring of truth, which is in eternal state of transformation." Here, the respondent defines

			a principle for structuring truth that involves the coordination of different systems of knowledge.

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[i] The word *abstraction* as used in the term *hierarchical order of abstraction* refers to the way in which conceptions increase in generality over the course of development. The concepts that occur for the first time at the single abstractions complexity order are abstract in a more particular sense; the new conceptions of this complexity order are defined in terms of qualities that are increasingly detached from the concrete.

[ii] As of January 2004, certified LAS analysts must maintain an agreement rate of 85% within 1/3 of a complexity level with a Certified Master Analyst (Dawson-Tunik, 2005).

[iii] We would be pleased to provide any interested party with a more detailed and thorough account of the conceptual content of these interviews.

Table 1: Age distribution of sample

Age	Frequency	Percent	Cumulative Percent
5	3	1.5	1.6
6	6	3.0	4.8
7	8	4.0	9.0
8	10	5.0	14.3
9	3	1.5	15.9
10	11	5.5	21.7
11	3	1.5	23.3
13	2	1.0	24.3
14	13	6.5	31.2
15	21	10.6	42.3
21-25	3	1.5	43.9
26-30	8	4.0	48.1
31-35	6	3.0	51.3
36-40	11	5.5	57.1
41-45	27	13.5	71.4
46-50	23	11.5	83.6
51-55	21	10.5	94.7
56-60	5	2.5	97.4
61+	5	2.5	100.0
Total	189	95.0	

Missing	10	5.0
	199	100.0

Table 2: Distribution of complexity level scores

Complexity order	Frequency	Percent	Cumulative Percent
Unelaborated RM	1	.5	.5
Elaborated RM	7	3.5	4.1
Transition to RS	3	1.5	5.6
Unelaborated RS	4	2.0	7.6
Elaborated RS	16	8.0	15.7
Transition to SA	4	2.0	17.8
Unelaborated SA	6	3.0	20.8
Elaborated SA	18	9.0	29.9
Transitional to AM	5	2.5	32.5
Unelaborated AM	11	5.5	38.1
Elaborated AM	19	9.5	47.7
Transition to AS	24	12.0	59.9
Unelaborated AS	26	13.1	73.1
Elaborated AS	42	11.1	94.4
Transition to SP	4	2.0	96.4
Unelaborated SP	2	1.0	97.5
Elaborated SP	5	2.5	100.0
Total	197	99.0	
Missing	2	1.0	
	199	100.0	

Table 3: Concept codes under the Ethics theme

A good leader…	**RM**	**RS**	**SA**	**AM**	**AS**	**SP**
shares	X			X		
is a good person	X	X				
is honest	X	X	X	X	X	X
is brave		X	X			
is kind		X	X	X		
is trustworthy		X	X	X	X	X
does not hurt others		X				
is courageous		X		X	X	X
is loyal		X		X	X	
is fair		X	X	X	X	
is not bad			X			
does not play favorites			X			
cares			X	X	X	X
is not greedy			X			
is not selfish			X			
stands up for his/her beliefs			X	X		
is respectable				X	X	
has integrity				X	X	X
does not discriminate against others				X	X	
is reliable				X		

does no harm	X		
is moral	X		
admits his/her mistakes	X	X	
is credible	X	X	
is humble	X	X	
respects others	X		
is respectful	X	X	
is ethical	X	X	
is forgiving		X	
is not too loyal		X	
negotiates honestly		X	
is faithful		X	
distributes recognition equitably		X	
recognizes diversity		X	
gives due credit		X	
has a good character		X	
admits his/her mistakes		X	
is candid		X	
is honorable		X	
is accountable		X	
is an autonomous moral agent			X

Table 4: Surface structures—representational mappings to single abstractions

Level	Goodness	Niceness	Smartness
RM	At this level a leader's goodness is understood in terms of simple good actions. Concrete concepts such as *good* or *bad* are combined in linear relations. Example: He has to be good. Not do bad things. [Why does he have to be good?] Because he's the leader. [And why is that important for a leader?] Because that is his job. (20176)	At this level a leader's niceness is understood in terms of simple ways of acting or being. Concrete concepts such as *nice* or *happy* are combined in linear relations. Example: They shouldn't make a big tantrum, and they should be nice to people. If you're not nice to people that could mean hitting people and punching people. That's mean. (20183)	Individuals performing at this level describe a leader's intelligence in terms of simple concrete abilities, such as *smart* or *gets good grades*. These are related in a linear fashion. Example: A leader should know that they're supposed to give other people turns. And do not take a long, long turn. And do not do things when you lead [in follow the leader] that people cannot do. Not so hard things. (30050)
RS	At this level a leader's goodness is understood in terms of simple good	At this level a leader's niceness is understood in terms of different ways of	At this level individuals describe a leader's intelligence as simple concrete

	actions explained with reference to situations and people. Concrete concepts such as *doesn't lie*, *nice*, and *not bad* get combined into multivariate and systematic descriptions of individuals or events. Example: You should believe the leader. They should not lie or anything. [Why is lying bad?] Because it can get you into more lies. So you need to not lie. Because if you lie, something bad might happen that would be the leader's fault. (2171)	acting that vary in different situations and with different people. Concrete concepts such as *talks to everyone*, *never fights*, and *isn't mean* get combined into multivariate and systematic descriptions of individuals or events. Example: A leader should not be so excited and silly that they are jumpy around their friends because that will embarrass them. You can be so excited to lead that you will not even know that you are being silly and you will keep doing it while you lead and they will be really embarrassed so they will not	competencies that the leaders use. Concepts such as *good at math*, *knowing secrets*, and *listening to the teacher*, are combined into multivariate systematic descriptions of individuals or situations. Example: They should be smart because they are telling people what to do. So, they need to have a good sense of direction [literally] and know what they are doing and know where they are leading everybody. (30008)

		really want to do it any more. (30204)	
SA	At this level a leader's goodness is explained in terms of simple abstract qualities or traits. Traits such *responsible* or *trustworthy* serve to organize systems of concrete concepts and descriptions. Example: Good leadership would be, responsibility. So, like, take care of your teammates, and like think before you do stuff. [So how would that help the leader?] It would help him, in being responsible in life. It would make it easier for him and his teammates to be responsible. They would all follow	At this level a leader's niceness is described in terms of simple abstract qualities or traits. Traits such *kind* or *caring* serve to organize systems of concrete concepts and descriptions. Example: A leader should help people through difficult times and help them understand what is going on around the world, helping then with their homework or, stuff like that. A leader should be caring because if people don't get help then they will start getting depressed and stuff. (10339)	At this level the leader's intelligence is described in terms of simple abstract capabilities or traits. Capabilities such as *making good decisions* or being *focused* serve to organize systems of concrete concepts and descriptions. Example: A leader is a person that knows how to actually lead somebody in the right way. A person that really studies a lot, is all about business, and not about telling jokes all the time. They just keep everything squared away. If it is a student, it's getting good grades. (10108)

	rules, you know, show up on time, get good grades and stuff. (10334)		

Table 5: Surface structure for three themes—abstract mappings to single principles

Level	Ethics	Style	Cognition
AM	At this level, ethics are spoken of as though they are fixed values or character traits. Abstract ethical conceptions such as *responsible*, *trustworthy*, and *considerate* are related to other concepts in a linear manner, forming propositions comprised of a few logically related abstractions. Example: A good leader puts his people first. That means that they are more important than yourself. Not like they have more power than you, but sort of like…you care for them before you care	At this level, leadership styles are often spoken of in terms of personal motivation or as though they are fixed personality traits. Abstract conceptions of leadership style, such as *dedicated*, *willing to comprise*, and *focused* are related to other concepts in a linear manner, forming propositions comprised of a few logically related abstractions. Example: Leaders need to be devoted…to be able to make sacrifices for… the people they are leading. What	Respondents performing at this level focus on basic, stereotypic cognitive capacities, such as *intelligence*, *common sense,* and *problem solving,* which are related to other concepts in a linear manner, forming propositions comprised of a few logically related abstractions. Example: A good leader is someone who can think outside the box. They do that so they can have a lot of ideas. Leaders are intelligent and want to be certain. If you think one way, it is

	for yourself. That is kindness. Leaders need to [be] honest and they should act so that the people they are leading respect them. They should be fair, too. (30007)	makes a good leader would be kindness, too—being willing to compromise. Also, a leader needs to go forth. A leader cannot just stand back because the leader is some[one] who leads people forward into any form of activity. So, they take certain risks. (30046)	obviously not going to work. And everyone thinks different and leaders need to know that. So, if you cannot think outside of the box, you can't solve problems. And you won't understand people because if you only think in one way, only [a] few people are going to think like you. (30054)
AS	At this level, ethics are often spoken of as though they are personally chosen values that can apply differently in different contexts. Sets of abstract ethical conceptions are coordinated in fully elaborated multivariate systems of abstractions. Conceptions such as *good*	At this level, leadership styles are seen as more differentiated, contextualized, and malleable than at lower levels. Sets of abstract conceptions of leadership style are coordinated in fully elaborated multivariate systems. Conceptions such as *pragmatic*, *process-focused*, and	The cognitive capacities that are mentioned for the first time at this level tend to be multidimensional and to incorporate a variety of psychological insights. They include concepts like *recognizing valid and useful knowledge*, *anticipating consequences,*

	character, *integrity*, and *accountability* are coordinated with other concepts in a structure that specifies multiple relations between conceptions. Example: It has to do with being truthful to yourself, to others…being clear about what you stand for, whether people agree with it or not—the opposite of just popularity. It's about being who you truly are in there. It's integrity and character that makes a leader. I think they need awareness of things and [the] people around [them]—seeing beyond just what you care about or just what impacts you,	*works across boundaries* are coordinated with other concepts in a structure that specifies multiple relations between conceptions. Example: A good leader needs to have a clear vision of where he or she wants to go with the organization—how those goals connect to the greater agency goals…how they interlink with that vision of other organizations…and other important external issues. But having the vision is just the first step, unless you do something with it—you know, the flashing symbol kind of thing—and so, translating that into an	and *forecasting outcomes.* These are coordinated with other concepts in a structure that specifies multiple relations between the conceptions. Example: Leaders need to create organizations where people are empowered, where they can work outside of organizational bounds…[where] you work toward the corporate good—not within a hierarchical system—where social networks are strong and you are encouraged both formal[ly] and informal[ly]. Because, in order to get the mission done most effectively, you

	and what you impact. It's an awareness of the diversity of people, which involves seeing past their surfaces into their core. You've got to be in tune with an ethical sense and be honorable. You've got to know that it's more than the room that you sit in and the meetings that you go to. It's just other stuff that we never want to think about—except maybe in our subconscious or [when] those of us who do stay up at night sometimes, because we're bothered, think about it. In the face of that, you have to have courage to sacrifice for what is true and right.	action plan, switching to the process while remaining true to that vision. That requires knowing the talent in your workforce, making sure they understand your vision…but being able to set the standards and get them moving out on it is the real challenge. That requires, again, good communication up and down. It requires trust. It requires tolerance, nudging, cajoling, incentives and all of that…what's the word…stewardship. But generally, folks are willing to move forward if they respect your authority—not because they fear you, but because	have to have… multiple perspectives…. The leader needs to be up to date on the relevant facts of the problem, thinking broadly, making predictions based on all kinds of input. (021)

	(109)	you've helped them to understand what the outcome is going to be and how important their role is. (103)	
SP	At this level, ethics are often viewed from an extra-institutional perspective. Individuals performing at this level coordinate systems of abstractions, sometimes in terms of overarching conceptions or general principles. Conceptions such as *moral atmosphere, autonomous moral agent, conventional ethical norms*, and *the moral perspective*, subsume systems of abstractions and facilitate their coordination.	At this level, leadership styles often either have a developmental component or are viewed from a developmental perspective. Individuals performing at this level begin to coordinate systems of abstractions, sometimes in terms of overarching conceptions or general principles. Conceptions such as *actualizing the organizational culture* and *reformulating the meaning of the mission in terms of present realties* subsume systems of abstractions and	Individuals performing at this level often focus on the ways in which the organizational environment either influences or makes demands upon the cognitive competencies of leaders. They coordinate systems of abstractions, sometimes in terms of overarching conceptions or general principles. Conceptions such *nurturing the development of different forms of intelligence* and *coordinating different areas of expertise* subsume systems of

	Example: Leaders take on more responsibility as moral agents than the rest of us, so they need to have the capability to act autonomously. That means they need to be able to take a step back and look at the big picture and the long view. Where will these decisions take us? Where will we end up if we keep doing what we are doing? Is that place morally acceptable? Is it just? Is it right? What will the next generation think of the legacy we've left? Without that broader perspective a leader is stuck thinking in the short term and will be unable to see the	facilitate their coordination. Example: I think, really, at the very top of an organization there are… two kinds of leaders: there are those that are externally focused and those that are interested in internally aligning the personnel to that external focus. The best leader would be both. I think, by nature, most leaders at the very top are externally focused. They are primarily focused on their customers and the mission, whoever those are and whatever that is. They are focused on their competitors with almost equal passion, and they're focused on the	abstractions and facilitate their coordination. Example: Good leaders just see things other people don't see. They see below the surface to the core essence of a thing. I think they are intellectually creative, which is important—very important, because most often the solutions to the really important problems are not linear solutions, even where it's a logical problem. Leaders need to pull from a very broad range of knowledge and forms of intelligence while keeping the mission in view. They need to be able to see into the

	repercussions and consequences of what they are currently engaged in. Nobody wants to be a bad guy and leave a legacy of injustice in his or her wake. But sometimes having a limited view can keep important issues off your radar. You see, fairness isn't about simply treating those around you in an equitable manner, although that is part of it. Fairness also involves looking out past your immediate context and seeing the ramifications that radiate spatially and temporally from the decisions you make. It means trying to do the thing that would do justice to everyone, and I	market environment for buyers and everything else. They're closing a loop around reality—defining and redefining the mission in relation to that focus. But that type of skill or quality tends not to be found in people who are interested in personnel process and alignment. So, very often you need two people at the top—one who has a kite and one who has a string. Ideally, maybe, one person could do both. The kite is externally focused—creative, entrepreneurial, a risk-taker, and visioning mission definer. The string is someone who says "okay, now how are we going to do	future; make predictions on current economic [and] technological trends. They need to grasp that whole technical area. They also need to feel out the interpersonal complexities of the organization…what it is capable of in that capacity. They need the facts and the frameworks. (104)

	mean everyone, that could possibly be affected by it. It's all tall order but you've got to try your best.	this? How are we going to get from point A to point B?" And that person tends to be interested in, above all, talent, recruiting and retaining talent, and the culture of the organization. (104)	

Figure 1: Developmental maieutics—spirals of research and application

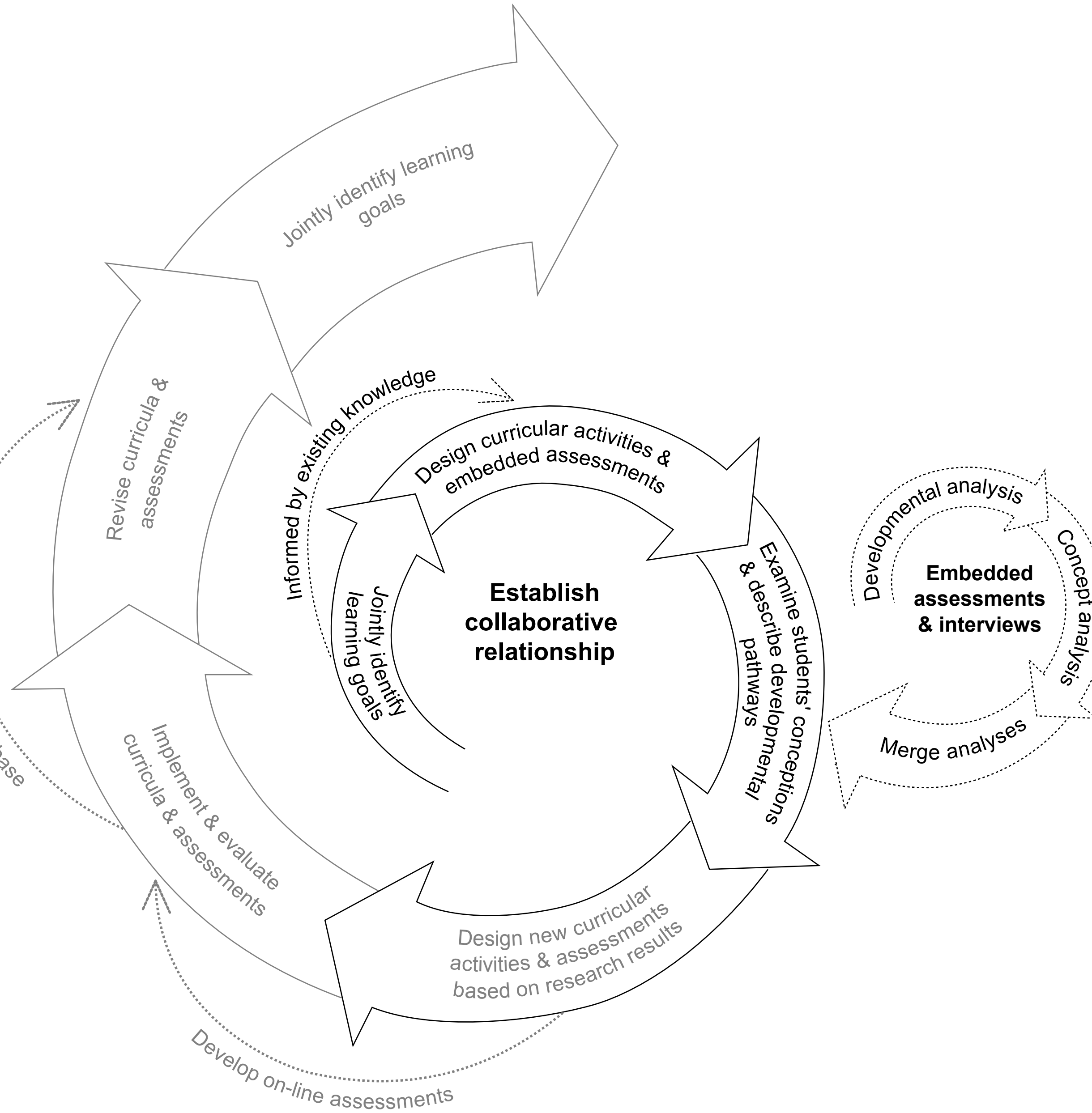


Figure 2: The relation between completed years of education and complexity level for 190 respondents

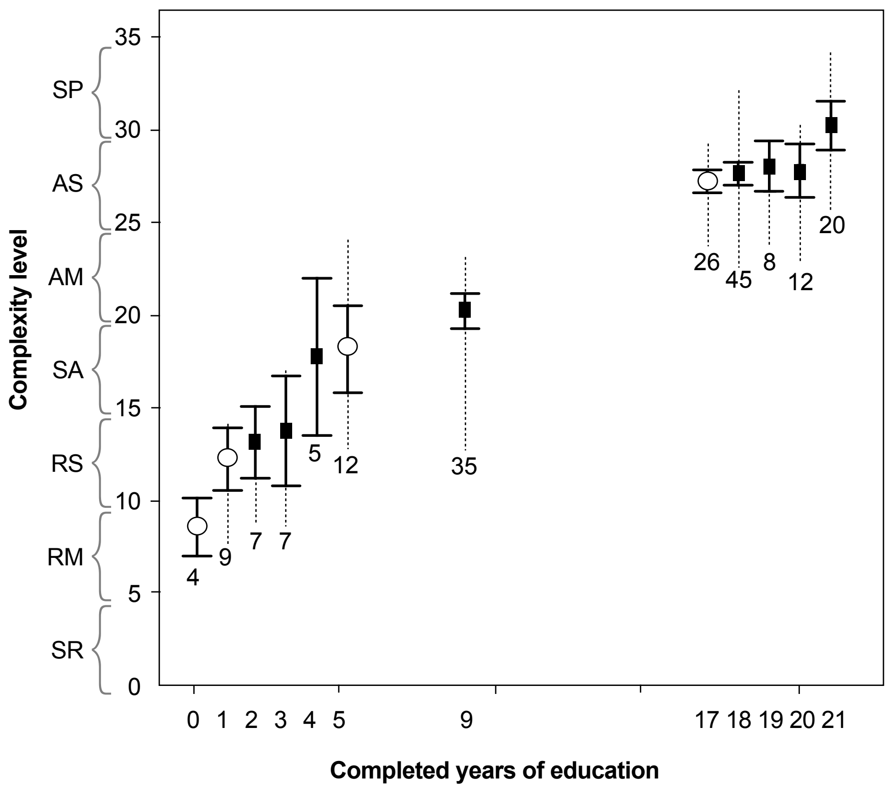
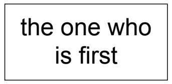


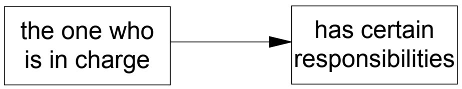
Figure 3: Evaluative reasoning about leadership: Domain structure

Developmental logic	Domain structure



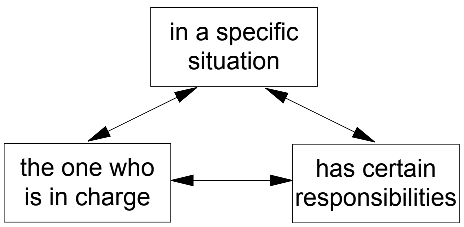
Single representations (SR)

At this level, leaders are described as individuals who are literally in front of other people or who get to go first. The game, follow-the-leader, may be mentioned. The tasks of leadership are not mentioned. The role and the person are not distinguished.



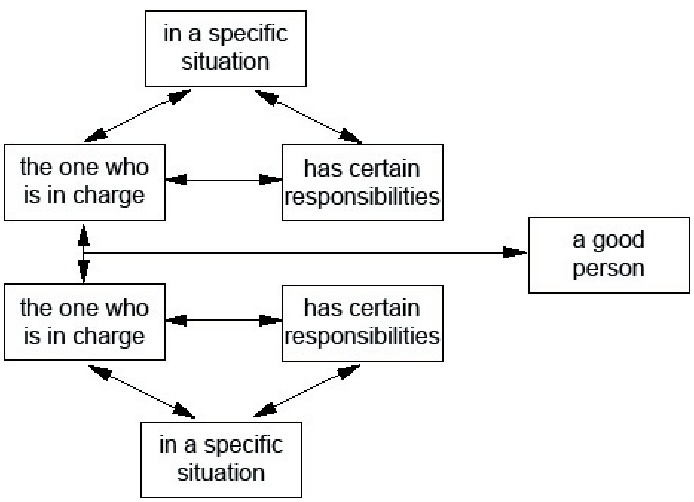
Representational mappings (RM)

At this level, leaders are described as individuals who are in charge of other people. Leaders are seen to have certain concrete responsibilities (things they should do or get to do, or ways they should act), which are elaborated in lists of simple behaviors: being nice, being smart, being strong, sharing, being liked by the teacher, etc. These behaviors are described in terms of specific occurrences that are observed (and preferred) by the respondent.



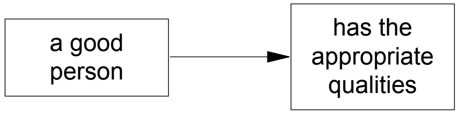
Representational systems (RS)

At this level, leaders are described as individuals who are in charge of other people and whose responsibilities (things they should do or ways they should act) depend upon the situation and those involved in it. For example, a respondent performing at this level may assert that a leader should be brave because a given situation is dangerous and the followers won't be so scared if the leader is brave; or that a leader should be nice in order to keep the followers' happy so they don't stop following or fail in their task. Explanations remain tied to specific instances and situations, typically those observed (and preferred) in the life of the respondent.



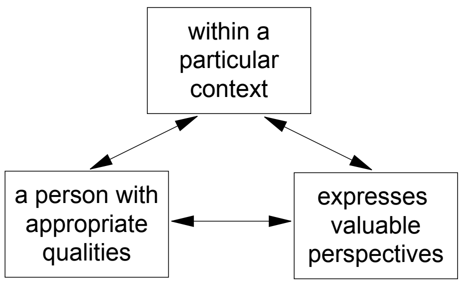
Single abstractions (SA)

At this level, leaders are often described as *good persons*. Good leaders are expected to do what *should* be done (what is right or appropriate). Goodness is an abstract personal trait that subsumes a variety of particular behaviors. Good leaders are viewed as having the ability to do the right thing in *general*. Goodness is not a situation-bound concrete behavior but a general quality or behavioral trait that is expressed in different specific behaviors depending upon circumstance.



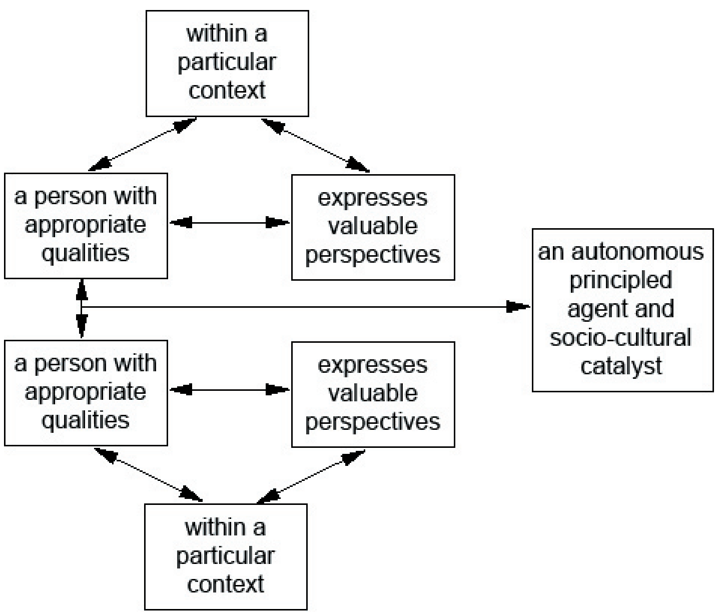
Abstract mappings (AM)

Leaders are described as individuals who possess a set of traits, qualities, or capabilities. These are presented in linear arguments or as lists. Respondents performing at this level are likely to assert that leaders should be personable, moral, level-headed, fair-minded, or able to lead by example. These assertions are justified in linear arguments that relate the qualities of the leader to the demands of leadership, including the psychological needs of followers.



Abstract systems (AS)

A good leader may be described as an individual whose personal qualities, skills, and perspectives are applied flexibly in particular contexts. For example, a personality trait like *confidence* may no longer be regarded as an absolute good, given the reality that confidence is inappropriate in some contexts—such as situations in which the information required to make a given choice is indeterminate. In other words, respondents performing at this level may argue the leaders should sometimes doubt their ability to know. Because specific qualities are now justified relative to contexts, traits may be seen as valuable in one context and detrimental in another. In this way, the validity of an individual leader's perspective, insight, and capability is constrained. Being sensitive to context (having the flexibility to adjust to cultural, personal, and political factors) is stressed as primary.



Single principles (SP)

A good leader may be described as an individual who maintains his or her integrity as an autonomous principled agent in a variety of contexts. Leaders orient their actions around highly abstract principles that can be employed to coordinate multiple perspectives. This coordination of perspectives makes it possible to integrate the demands of different contexts within a common framework. Such a framework, because it emerges from the evaluation of local norms in light of universalizable normative processes and guidelines, may transcend current standards.

Figure 4: Surface structure—themes

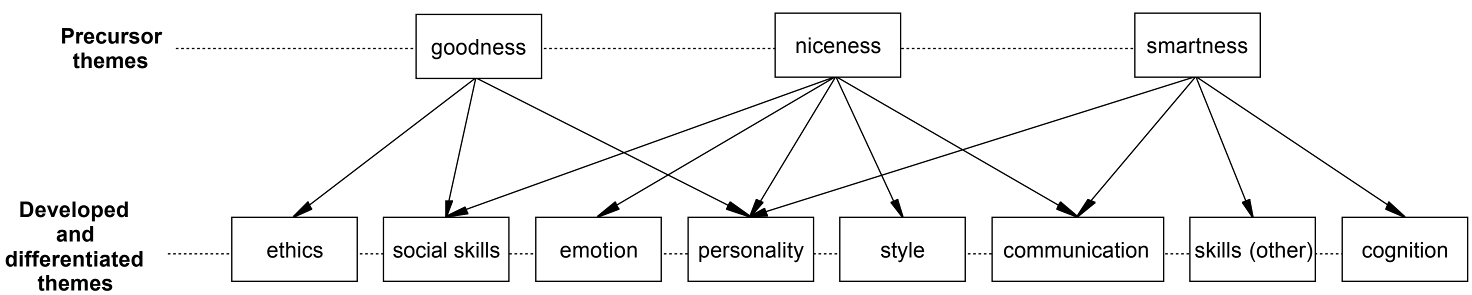


Figure 5: The relation between ILT factors/traits and thematic strands