But Is It Science?

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Abstract

This paper is based on the findings from a multifaceted study undertaken to address the strong need for empirical evaluation of Waldorf education. There is growing interest in the Waldorf method among many parents and educators because they believe it more successfully engages students and supports meaningful learning than do mainstream methods. Yet these parents and educators have little first-hand knowledge of Waldorf pedagogical principles or the founding father's philosophy. Increasingly, they find themselves caught between the extremes in a debate others have long-engaged over Waldorf education: a debate that can be summarized at one extreme as adamant opposition to the peculiar philosophical background of Rudolf Steiner, whose beliefs, critics claim, constitute "pseudo-science;" and at the other extreme as a firm conviction that any shortcomings in student achievement under Waldorf methods is the result of shortcomings in implementation of the Waldorf curriculum as intended – and decidedly not because the curriculum is "pseudo-scientific."

The purpose of this study was to use recognized and accepted methods of inquiry and investigation to uncover the nature of Waldorf science education and to evaluate its applicability to mainstream science education. The study began with four primary questions: (1) How does the Waldorf science curriculum align itself with state and national science standards? (2) What are the perspectives of Waldorf students, teachers, and parents regarding science education in the Waldorf context? (3) How do Waldorf students' scientific reasoning and problem solving skills compare to those of their counterparts in mainstream educational settings? (4) Does Waldorf offer a viable form of science education?

The primary focus of this paper will be on the viability question. However, a monograph of the full study is available at www.csus.edu/indiv/j/jelinekd .

Introduction

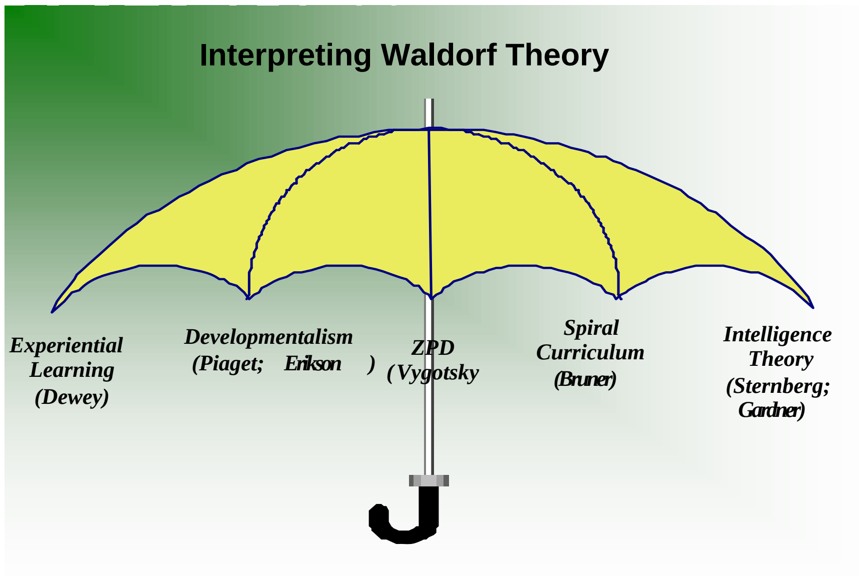
Rudolf Steiner started the first Waldorf School more than eighty years ago for the children of workers at the Waldorf Astoria Cigarette Factory in Stuttgart, Germany. The lectures and discussion sessions he conducted with the school's first teachers, combined with a curriculum outline based on Steiner's view on the nature of human development, were and remain the cornerstone of Waldorf education. Viewing the teacher as an artist and the classroom a living canvas upon which the teacher-artist would render breathtaking creations, Waldorf education infused war-torn Germany with a new view of the classroom where students engaged in artistic activities and got out of their seats to learn. Waldorf education expanded rapidly in Europe, then the United States, where it continues to flourish today.

A relatively new twist to the Waldorf expansion is the introduction of its methods into mainstream public school settings. This heightens its visibility and raises many questions about its viability. Is its approach to teaching and learning science, for example, sound and valid, and how do we know? Hitherto anecdotal evidence has attested to Waldorf's effectiveness, substantiated occasionally with an internal Waldorf study, but hardly representing empirical authenticity. Waldorf studies to date have generally taken the form of "proof" generated by Waldorf advocates or diatribes by disenchanted parents whose children were "wronged." In either case the lack of empirical evidence has limited the potential significance of the findings.

This study was undertaken to address the strong need for empirical evaluation of Waldorf education. There is growing interest in the Waldorf method among many parents and educators because they believe it more successfully engages students and supports meaningful learning than do mainstream methods. Yet these parents and educators have little first-hand knowledge of Waldorf pedagogical principles or the founding father's philosophy. Increasingly, they find themselves caught between the extremes in a debate that can be summarized at one extreme as adamant opposition to the peculiar philosophical background of Rudolf Steiner, whose beliefs, critics claim, constitute "pseudo-science;" and at the other extreme as a firm conviction that any shortcomings in student achievement under Waldorf methods is the result of shortcomings in implementation of the Waldorf curriculum as intended – and decidedly not because the curriculum is "pseudo-scientific." The polarity of this debate, coupled with the unreliability of other sources of information about Waldorf teaching methods, fails to serve those who are intrigued by the methods and their apparent success, but unable to quantify whether they really work.

The purpose of this study was to use recognized and accepted methods of inquiry and investigation to uncover the nature of Waldorf science education and to evaluate its applicability to mainstream science education. The study drew upon a variety of professional and lay perspectives within the academic community, mainstream education, and the Waldorf movement. Overall, the focus was on gaining an understanding of Waldorf's perspective of knowing and doing science and on placing the findings within the broader context of mainstream science education.

Theoretical Underpinnings



Before investigating Waldorf education, it was important to find a conceptual basis by which to interpret it –an "umbrella" of well-grounded theories that would afford the opportunity to draw upon many empirical studies and make inferences about parallel aspects to Waldorf.

Experiential Learning Theory has its roots in the work of John Dewey, who contended that people solve problems by conducting inquiries. Dewey argued that an "organic connection between education and personal experience" (John Dewey, 1938) was necessary to guide practice, and he advanced a perspective that synthesized both theory and practice. He advocated free activity versus external discipline, learning through experience as opposed to learning from texts, and acquisition of skill in context rather than in isolation or by drill (p. 20). Logic, rationality, the scientific method, and discovery of intrinsic meanings signify important elements of Dewey's philosophy (Dewey, 1930; John Dewey, 1938).

Developmentalism is a fundamental basis for the Waldorf pedagogy, and studies have been conducted comparing Steiner's developmental theory to Piaget and others (Steiner, 1919,1976; Piaget 1931; Bruner 1971; Piaget 1973;Elkind,1981). Like Piaget, Steiner's theory argues that the pedagogy should be aligned with developmental characteristics so that age-appropriate activities are introduced in a manner conducive to the child's levels of physical, emotional, and mental maturation. But Piaget and Steiner part company on the basis for developmental stages, for Piaget's basis is cognitive, and Steiner's is philosophically spiritual. Steiner argued that the child's age parallels advancing degrees of consciousness incarnating in the physical body, and that the teacher's role is to guide proper incarnation through correct and specifically selected pedagogical content.

The Zone of Proximal Development (ZPD) (Vygotsky, 1978) in some ways parallels Steiner's view that the adult should be a central presence in the classroom (Steiner, 1967). Much of Vygotsky's work singled out the dynamic social environment in which students interact with one another and with teachers. This resonates in Waldorf methods, where teachers are specifically trained to recognize a child's social orientation and to understand the pedagogical possibilities available to lift the child to a new level of activity and consciousness, given his or her social orientation.

The Spiral Curriculum emerged out of Jerome Bruner's leadership in the Woods Hole Conference of 1959, and from his classic *The Process of Education* (Bruner, 1960), which gave rise to the human development theme in science education. Bruner, like Steiner, contended that an emphasis on too much academic learning was counterproductive to the development of critical thinking faculties because it emphasized pre-selected and pre-designed materials, such as worksheets and step-by-step activities, over "figuring out how to use what you already know in order to go beyond what you already think" (Bruner, 1983). Part of the problem of overly prescriptive educational methods is the tendency to feed too much conceptual information to students at one time. Bruner argued that there is a basic "structure" to each concept which should be revisited by the child again and again over time, because as the child develops, so will the structure of the concept. In other words, the child will gain an ever-deepening understanding of the concept provided it is not prematurely drilled into his or her brain. Like points on a spiral, the concepts come around again, gaining momentum in complexity and meaningfulness as they do so. It would be incorrect to say that Rudolf Steiner advocated a spiral curriculum for all the same reasons Bruner did, but some similarities exist.

Intelligence Theories, particularly Robert Sternberg's Triarchic Intelligence Theory (Sternberg, 1997) and Howard Gardner's Multiple Intelligences Theory (Gardner, 1993), provide another lens through which to consider Waldorf. Sternberg distinguishes among three basic kinds of thinking – analytical, creative, and practical and asserts that the successful *transfer* of knowledge from one particular context to another is dependent upon integration of all three types of thinking. Gardner's Multiple Intelligence (MI) theory is in some ways an expanded version of Sternberg's theory, comprising eight "intelligences": logical-mathematical, linguistic, musical, spatial, bodily-kinesthetic, interpersonal, intrapersonal, and naturalist.

While obvious parallels of educational implications from these theories of intelligence exist, that is really where the similarities stop. Steiner's rationale for his theory of human intelligence is derived from perspectives he claims to have gained from clairvoyant investigations in the spiritual world.

Methods

Research Questions

The four research questions of the study were:

1. How does the Waldorf science curriculum align itself with state and national science standards?

2. What are the perspectives of Waldorf students, teachers, and parents regarding science education in the Waldorf context?

3. How do Waldorf students' scientific reasoning and problem solving skills compare to those of their counterparts in mainstream educational settings?

4. Does Waldorf offer a viable form of science education?

Data (Theoretical rationale)

We used the metacognitive theoretical perspective as our foundation for the interview and survey protocols used in the study. Metacognition is appropriate because it encompasses the same variables on which this study is focused: affective, cognitive and behavioral factors (Hunt, Frost, & Lunnenborg, 1973; Marzano et al., 1988; Sternberg & Spear-Swerling, 1996). For purposes of this study, we define affective factors as Waldorf teacher attitudes, interest, commitment, and attention to teaching science; cognitive factors as understanding of scientific concepts, principles and processes of knowledge acquisition and knowledge production.; and behavioral factors as teaching and learning perspectives such as evaluation, planning, and the promotion of critical thinking (Ennis, 1985; Goodlad, 1984; Marzano et al., 1988). These three groups of factors were the basis for our survey content and methods in this part of the study.

Research suggests that teachers who lack confidence in teaching science cannot teach science meaningfully. This is an affective variable the study sought to measure. Novice teachers, in particular, will often resort to "safe," explicit teaching strategies (Cunningham, 1995) when uncertain about the content. Further, teachers' beliefs, values, and biases about how to teach science significantly affect how they view themselves as teachers. Once established, these points of view are difficult to change even when inaccuracies and misinformation are pointed out (Goodman, 1988; Nespor, 1987; Thomas, Pedersen, & Finson, 2000). Even tremendous investments in instructional change, curriculum materials and related equipment have not significantly changed the teaching habits of most teachers (Abell, 1989; Barnes & Barnes, 1989; Otto, 1997), a testament to the power of stereotypic perceptions to influence how teachers understand the nature of science, and how they approach teaching the subject (Thomas, 2000).

For the current research project, this raises particularly interesting questions. What are the implications of these affective variables in teaching science? Could there be a tendency to approach scientific experimentation with a "safe" but ultimately naive inductivist attitude? What if discovery or learning is void of social negotiation? Is there a practical threat that science in the classroom could become an inauthentic representation of the work of the real scientific community? Could a failure of confidence on the part of the teacher lead to an inaccurate portrayal of scientific processes and concepts, or to teaching science as a series of absolute truths beyond reproach (Cunningham, 1995)?

Many Waldorf educators argue that questions like this are really red herrings because school science is not about replicating real science, but about developing capacities. On the other hand, extensive research suggests that "an ordinary degree of understanding is routinely missing in many, perhaps most students" (Gardner, 1991). In Harlen's classic and still highly referenced book *Taking the Plunge* (Harlen, 1985) it is evident how prevalent misconceptions in science are, often exacerbated by teachers own misconceptions. AAAS 2061 Benchmarks (American Association for the Advancement of Science, 1993) also examines the prevalence of misconceptions and outlines a rigorous process to change this, although teacher and student misunderstandings continue to abound (Stigler & Hiebert, 1999; Wiggins & McTighe, 1998).

Educational researchers are clearly no strangers to affective factors, and there is a seeming overabundance of methods from which this study might have chosen. We reviewed existing research on attitudes toward instructional variables (Allen, Klingsportn, & Christensen, 1980; Durkee, 1974; Sparks & McCallon, 1974); in specialized programs (Yager, 1982); influenced by classroom climate (Haukoos & Penick, 1983); and toward science and scientists (Fraser, 1978). These studies and their results produced ambiguous findings, and when those studies involved affective factors in science education serious issues of confidence and validity arose. Munby (1983) examined the use of the Scientific Attitude Inventory (SAI) in thirty studies conducted over a ten year period and concluded " ... not only is the field of measuring attitudes replete with instruments, but that these instruments are used in a rather cavalier fashion, without heed to their reliability and validity" (p. 161).

The Revised Science Attitude Scale (Thompson and Shrigley, 1986) has addressed many of these limitations in reliability and validity, and served as a model for the Waldorf survey protocols that were developed for this research. The Science Attitude Scale was supplemented with more conceptual-based questions since it seems that a shortcoming in much of the science survey literature is that it often stresses affective components at the expense of conceptual development, i.e., the cognitive domain of metacognition. Cognition deals with conceptual learning, with an underlying premise that the *concepts* being learned are accurate.

While the Waldorf survey and interview protocols were not designed to specifically test teacher conceptual understandings (or misunderstandings), they do include questions to ascertain Waldorf teachers' perceptions of the role of conceptual understanding and development in science education. The protocols which have been developed have served the purpose of gathering data to elucidate the metacognitive factors presented herein.

Whether Waldorf students perceive and reason about the world differently is an intriguing question, and one way to approach it is through the domain of *logical reasoning*, traditionally viewed as a central element in intelligence (Sternberg, 1997). The kinds of logical reasoning tests to administer becomes a central concern, however, as exemplified in Lesser, Fisher and Clark (1965) who found that when a cognitive performance task requires verbal understanding (instruction), manipulation, or elaboration, logical reasoning is subject to four factors: (1) how familiar its content is to the audience; (2) the age of the person; (3) the format used to express it; and (4) the plausibility of its assertions in terms of one's world knowledge and cultural norms. In short, the ways of stating logical reasoning tasks is pivotal to performance.

For the above reasons, non-verbal as well as verbal tasks were administered to 4^{th}, 6^{th} and 8^{th} grade students in this study. The non-verbal tasks are based on the Test of Non-Verbal Intelligence (TONI) (Brown, Sherbenou, & Dollar, 1982), which is considered a language-free measurement of cognitive ability. The non-verbal items in this task require subjects to solve problems by identifying relations among abstract figures. Each item consists of (a) a stimulus set of figures, and (b) a set of response choices. The stimulus set presents a set of figures in which one or more of the figures is missing. The subjects complete the set by selecting the correct figure from the response choices (either four or six response alternatives). The symbols depicted in the non-verbal logic test include one or more of the characteristics of shape, position, direction or rotation, contiguity, shading, size or length, movement and pattern within the figures.

The verbal logical reasoning task used in this study was an adapted version of the Cornell Class-Reasoning Test (CCRT), Form X, (Ennis, 1985). The CCRT test consists of multiple-choice items, with 30 minutes allocated for the test administration. The tasks focus on "deductive logic," which has been considered fundamental and pervasive in human thinking. Deduction implies that thinking involves the combination of existing information by following specific mental operations, as in addition or subtraction (Mayer, 1992). In deductive logic, the propositions or rules are given and the thinker uses the given information to derive a conclusion that can be proven correct. Mathematical proofs, for example, are deductive. Although deductive operations could be seen as tasks rather than theories of thinking (Mayer, 1991), they have an implied view of human thinking. For example, Mayer (1991) focused on the perspective suggested by work in deduction that thinking involves combining information by using a set of psychological and mathematical operations. Mayer interprets thinking as the processing of premises by using specific operators--similar but not identical to formal logical operators (Mayer 1991).

The main focus of the deductive reasoning approach is the syllogism, which consists of two premises and a conclusion. There are three types of syllogisms that are often mentioned in textbooks on logical reasoning: (a)*class syllogisms*, such as "all A are B; all B are C; therefore all A are C"; (b)*linear syllogisms*, such as "A is greater than B; B is greater than C; therefore A is greater than C"; and (c) *conditional syllogisms,* such as "if *p* then *q*; *p* is true; therefore *q i*s true." The present study focuses on the first type of syllogism, the *class syllogism,* due to its focus on part-whole relations of class-membership and inclusion (Piaget, 1969). According to Waldorf pedagogy, an underlying principle of teaching is to proceed from the whole to the parts (Steiner, 1966). It was therefore intriguing to investigate where or not there is evidence of logical patterns emerging from this approach.

The nature of the part-whole relation has been a source of controversy and confusion in terms of what role it plays in logical thinking (Lyons, 1977; Winston, Chaffiiin, & Herrmann, 1987). Although most researchers agree that the part-whole relation is of prime importance in human cognitive processing, some senses of the relation seem to appear earlier than others; that is, some are more primitive developmentally than others (Iris, Litowitz, & Evens, 1988). A majority of studies in the field of the development of logical reasoning have been concerned with the question of the relative extent to which a child focuses on either the part or the whole in perception. Half a century ago Werner (1957) claimed that perception proceeds from a diffuse organization characterized primarily by "qualities-of-the-whole" into an organization in which the essential feature is a decisiveness of parts. Early studies done by Hemmendinger (1953) reported data attesting to the tendency of American children to focus predominantly on the whole configuration as opposed to the individual parts in visual perception. Heiss (1930) reported on the greater difficulty the younger groups in his study had in finding small shapes embedded in a large configuration. Based on this finding, Lowe (1973) hypothesized that this whole-oriented perception has a possible impact on the perception of the parts and that younger children, when their attention is directed to the parts of a larger configuration, perceive the parts in terms of qualities of the total configuration. Their perceptual functioning results in a specific, predictable dissimulation of the parts--i.e., the parts shift in appearance to look like the larger wholes.

Science problem-solving skills, the third area of focus in our assessment of Waldorf students, was derived from the Third International Math and Science Study magnet task (Harmon et al., 1997). TIMSS is the largest and most comprehensive international study of school math and science ever conducted, providing a rich resource of validated science assessments and data bases. Conducted in 1995, TIMSS compared 42 countries at three grade levels in multiple dimensions. The magnet task represents just one of 13 practical tasks to assess student content knowledge and problem-solving abilities. This is important to keep in mind when the Waldorf student results are compared to TIMSS. Obviously a more comprehensive study is needed to do an adequate comparison.

On the other hand, TIMSS findings have revealed many rather intriguing considerations for this study. For example, there is strong evidence to suggest an inverse relationship between content and achievement; i.e., those who performed highest were not those who were taught the most content, had the most homework or the most instructional time allotted to the subject. Simply put, the highest performing countries are not the countries who taught the most (in content or time). These findings bode well for Waldorf which argues against the “more is better” approach to education, where homework in the early years is frowned upon and textbooks are generally not used. TIMSS results also validate the National Assessment of Educational Progress (NAEP) data that no gains have been made in higher-order thinking or scientific performance for the past quarter century(U.S. Department of Education, 2003). From TIMSS survey data U.S. teachers focus 60% of their teaching on skills and 20% on thinking; 95% on practice procedures, less than 5% on concept application and less than 2% on inventing/thinking. By comparison the Japanese teachers focus 25% on skills and 75% on thinking,; 40% on practice, 10% on concept application and over 45% on inventing/thinking (Wiggins, 2001). The significance of these statistics is clear when performance scores of the two countries are compared.

Japan (and almost all other countries) outperformed the United States in understanding and performance, leading to the conclusion that "…the felt obligation to cover content … is not an effective strategy" (Wiggins, 2001). Exactly where Waldorf students compare will be impossible to say based on the data from a single TIMSS task, but as the data will show below, on that single task they have performed above the U.S. and in some cases close to Japanese students. This means, that further investigation – perhaps a larger scale comparison – would be well justified.

Analysis

Both qualitative and quantitative methodology were employed to collect a variety of perspectives of interpretations; statistical testing included measures of central tendency, variability, frequency distributions, correlations, regression, and t-tests. Qualitative analysis relied on Constant Comparative Analysis (CCA) (Strauss, 1987).

The following table summarizes the data, procedures and analysis.

Study Component	**Data**	**Procedures**	**Analysis**
Curriculum & Assessment	1. Waldorf Science Curriculum 2. Curriculum Rating Tool 3. Waldorf Science Kits 4. Science Kit Evaluation Questions.	• Curriculum reviewed by external evaluators using *Science Curriculum Rating Sheets"* A 1 to 5 Likert scale + Narrative Feedback. • Kits field Tested by 25 beginning teachers. Narrative responses to 5 criteria.	• Qualitative: Content analysis of narrative and informal feedback. Coded & categorized using Constant Comparative Analysis (CCA). • Quantitative: Central Tendency, Variability, & Frequency Distribution
Surveys and Interviews	1. Focus Group Interview Protocol 2. Waldorf school delegates questionnaire 3. Interview Protocol for Teaching Waldorf Science Lessons 4. Open-ended Questions: Science Teaching in Waldorf Schools 5. Waldorf Science Education Survey	• Interviews conducted in teacher's school setting, taped and transcribed. Representatives from all regions and Hawaii were interviewed. • Survey administered to 50 Waldorf School across North America; 240 respondents.	• Qualitative: Constant Comparative Analysis (CCA) of all verbal and written narratives • Quantitative: Central Tendency, Variability, Frequency Distribution, Correlation Coefficient, Regression Analysis & Chi-Square.

Study Component	Data	Procedures	Analysis
In the Classroom	1. Non-verbal Logical Reasoning Task 2. Verbal Logical Reasoning Tasks 3. TIMSS Magnet Task 4. Videotapes – Waldorf science lessons	• Administered tasks to 4th, 6th & 8th Grade Waldorf Students in representative schools on East and West Coast plus Hawaii. Videotaped complete lessons from representative teachers in different parts of the country. Coded and analyzed lessons according to Inquiry Analysis criteria.	• Qualitative: Constant Comparative Analysis (CCA) of student narrative data. Videotaped lessons coded according to, Inquiry Analysis codes, using 1 minute sweeps. • Quantitative: Central Tendency, Variability, Frequency Distribution, variance, *t*-test, and Chi-square.

The full results and discussion of these studies are provided in the monograph *Does Waldorf Offer a Viable Form of Science Education*, available at www.csus.edu/indiv/j/jelinekd . The remainder of this paper will focus on just those aspects of the discussion that seek to answer the question of whether or not Waldorf offers a viable form of science education.

Discussion

The following discussion is excerpted from the full discussion found in the monograph.

While it is possible to draw conclusions based on data we have analyzed and discussed up to this point, it will not quite satisfy the complexity of this question. Waldorf does not, for example, fully align itself with the national science standards, though as the reviewers point out, there are numerous favorable processes that support science as inquiry, so they gave *pedagogical appropriateness* and *science content* fairly high ratings, overall. On the other hand, some of the concerns the reviewers raised about questionable concepts would be reason enough for some critics to discredit Waldorf science education all together. The evolutionary notion that animals are the by-products of human development, that the spirit of man physically incarnated into soul qualities that manifested themselves into various animal forms, is highly suspect as a valid scientific theory. So is the geological position that earth evolved through Lemurian and Atlantean epochs and is now in its fifth post-Atlantean epoch. Or the theory that the four kingdoms of nature are mineral, plant, animal and man.

Of course, "mainstream" science textbooks are also "riddled with errors". Take, for example, the recent study of 12 popular science textbooks which found 500 pages of errors (Associated Press, 2001). "These are terrible books, and they're probably a strong component of why we do so poorly in science," said John Hubisc, the North Carolina State University physics professor who conducted the 2 year survey. However, this does not condone Waldorf's conceptual inaccuracies, but it underscores that if inaccuracies are the litmus test for disqualifying a particular curriculum then approximately 85% of middle school science textbooks used in the United States must be eliminated (Associated Press, 2001). However, a line can be drawn between conceptual inaccuracies that are subject to correction and pseudoscientific explanations that have no empirical grounding. For Waldorf to answer that it provides a viable form of science education it must provide a solid rationale for it's selection of "less" and "correctness". Some of its selections are dubious, but it appears that many Waldorf educators are unwilling to remove and replace erroneous information.

Though it is true that some Waldorf teachers demonstrated a high degree of scientific understanding and others a high degree of "Waldorf-specific" concepts (e.g., Steiner's view of evolution), the majority actually appeared to be struggling with the question about what should be taught and how it should be taught. There was struggle over whether Rudolf Steiner's teachings about science had any place in the curriculum, or if content to be delivered should be drawn from more mainstream sources. In actuality, the majority of Waldorf teachers we interviewed pointed to this latter choice as the more ideal; albeit they were uncertain about how to go about doing this. A resounding plea for assistance in this area was expressed. This is also evident in the relatively low ratings Waldorf teachers gave to their teacher preparation for science methods. Waldorf teacher educators claim to be responding to this need, but if Waldorf is to enter into the "viability of mainstream science education" one has to ask if traditional Waldorf teacher preparation is going to do it. The less experienced Waldorf teachers tend to be intimidated or swayed by the dictates of the more experienced to "teach Waldorf science this way". The more experienced tend to either expect the less experienced to get it together and follow in the footsteps of the wise, or they acknowledge that they've really only been winging it themselves all these years, and they wished there was more guidance. This need for more guidance, resources, connection with other perspectives, etc. rings throughout the movement -- suggesting the possibility for reform, albeit an uphill battle because of the adherence to the belief that much of what others say students should be taught is "not developmentally appropriate".

This raises one additional teacher perspective that heavily influences the "viability" question: many of the Waldorf teachers we surveyed and interviewed hold a strong bias that public school science education is inferior –void of imagination and inspiration where students are taught "dead" concepts through rote memorization, where the fostering of human capacities through integration of "the head, heart and hands" is absent. In several instances the justification for Waldorf education seems to be a diatribe against public schooling and the science education research community. Virtually no Waldorf educators we surveyed or interviewed kept abreast of current trends and research is science education. It is difficult to bring Waldorf to the table of science education discourse unless they step up and take their place.

When looking at Waldorf student performance it is understandable why it would be difficult to dismiss Waldorf science education as a viable method. Certainly based on the tasks administered in this study students performed impressively, demonstrating high levels of nonverbal and verbal logical reasoning, higher order scientific reasoning skills, confidence and intrinsic motivation. Whether these results will sustain themselves when more comprehensive investigations are conducted, or will transfer to other cognitive domains, remains uncertain at this point, but clearly further study is justified. Waldorf students should also be assessed for their science content knowledge. The prediction is that under grade six they will not perform high, which at this point Waldorf would argue is developmentally appropriate.

Conclusion

At the heart of the "*but is is science*" question lies a distinction between pseudoscientific and scientific thinking – a distinction made by accepting the current paradigm of what constitutes science. As Thomas Kuhn's (1962) classic theory of "paradigm shift" points out, there is an accepted "normal science" that the majority of practicing scientists adhere to, subject to shift if and when there is enough evidence and power to "overthrow" the existing paradigm.

Shermer's (1997) definition of paradigm is quite helpful: "A model shared by most but not all members of a scientific community, designed to describe and interpret observed or inferred phenomena, past or present, and aimed at building a testable body of knowledge open to rejection or confirmation." What is this current paradigm? Carroll's (2002) characterization of scientific theories captures it well:

> "(a) being based upon empirical observation rather than the authority of some sacred text; (b) explaining a range of empirical phenomena; (c) being empirically tested in some meaningful way, usually involving testing specific predictions deduced from the theory; (d) being confirmed rather than falsified by empirical tests or with the discovery of new facts; (e) being impersonal and therefore testable by anyone regardless of personal religious or metaphysical beliefs; (f) being dynamic and fecund, leading investigators to new knowledge and understanding of the interrelatedness of the natural world rather than being static and stagnant leading to no research or development… (g) being approached with skepticism rather than gullibility, especially regarding paranormal forces or supernatural powers, and being fallible and put forth tentatively rather than being put forth dogmatically as infallible."

Shermer (1997) offers additional clarifications of the scientific versus pseudoscientific thinking:

> "(h) anecdotes do not make a science; (i) scientific language does not make a science; bold statements do not make claims true; (j) the burden of proof for extraordinary claims is on the person making the claims; (k) unexplained in not inexplicable (i.e., just because it cannot be explained does not make it a true mystery of the paranormal); (l) appeal to ignorance (i.e., the fallacious argument that if you cannot disprove a claim it must be true); (m) drawing conclusions before the facts warrant it; (n) over-reliance on authorities; (o) either-or fallacy (i.e., if you discredit one position, your are forced to accept the other); (p) the need for certainty, control, and simplicity; (q) ideological immunity (or, to use Jay Stuart Snelson's definition: educated, intelligent, and successful adults rarely change their most fundamental presuppositions (Snelson, 1993)".

Using these features of the scientific thinking paradigm, what *could* Waldorf do to demonstrate its viability?

As a first step Waldorf should disregard Rudolf Steiner and Anthroposophy as the source of accurate scientific concepts. The basis for this recommendation is that Steiner's teachings do not pass the tests of empiricism (a,b,c and d), are not testable by anyone (e), have not changed much, if any, since Steiner introduced them (f), and rely on paranormal statements that cannot be verified (g). Accepting many of Rudolf Steiner's "scientific" indications in light of the absence of empirical evidence violates the core premises of the scientific paradigm. The anthroposophical argument is that Rudolf Steiner applied empirical investigations in the spiritual world where he garnered higher spiritual truths, but even if this turns out to be accurate it must be discarded as scientifically valid because it cannot be replicated by anyone. If and when the scientific paradigm can ever be overturned with an anthroposophical paradigm because a preponderance of empirical evidence demands it, anthroposophists will have reason to celebrate; but there is little in the current paradigm to suggest this is likely.

There is also an argument that Anthroposophy and Waldorf Education are inseparable. If that is true then it is difficult to understand how Waldorf could offer a viable form of science education. But many educators argue that the methods of Waldorf and Anthroposophy are separable -- public Waldorf educators have gone so far as to argue this point in court when challenged on separation of church-state issues. Legal ramifications aside, there is little doubt that a distinct separation from Anthroposophy is needed. Consider the anthroposophical tenets of developmentalism and evolution. Steiner's developmentalism is based on his teachings that children pass through three 7-year stages: the first characterized by the reincarnated human spirit adjusting to the physical world; the second by the incarnation of the "etheric" body with the physical body; and the third by the incarnation of the "astral" body. Steiner's evolutionary teachings suggest that throughout these developmental phases the human being is actually recapitulating evolutionary phases from previous epochs, dating back to pre-earth existence when the human spirit resided on ancient Saturn, Sun and the Moon. To Waldorf's credit there is no evidence that such ideas are taught to the children. There is evidence, however, that the rationale for the structure of the Waldorf curriculum is to properly guide the incarnating human spirit through these developmental and evolutionary phases; and that anthroposophical Waldorf teachers adhere to this rationale as a basis for why and what they teach.

By removing Anthroposophy the arguments of Waldorf's questionable philosophical foundation are removed and Waldorf can focus, instead, on the strengths of its methodology and ways to improve it. It should be noted, however, that rejecting Steiner and Anthroposophy as the source of accurate scientific concepts does not signify the rejection of the many exemplary Waldorf methods that have attracted the attention of innumerable parents, educators and academics. We concur, here, with a position expressed by Waldorf critics Dan Dugan and Judy Daar (1994): "It might be possible to establish schools that take many of the good Waldorf school ideas into a secular environment, but this could only be done by people not indoctrinated by Anthroposophical training."

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