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AUTHOR	Bamberger, Jeanne
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ABSTRACT

The paper discusses the use of music-based experiments to illuminate teachers' understanding of their own and pupils' informal ways of learning. The major objective of the paper is to help teachers understand students' learning processes. Because one central problem in academic research is that of finding the right questions, researchers should begin with the various ways children learn. In experiments, the teacher bases hypotheses on subjective awareness and interventions and then tests her hunches concerning the student's intuitive strategies. This process adds to a teacher's self-knowledge and increases understanding of the child's current knowledge and ways of learning. With this increased understanding, a teacher can help the child integrate his basic cognitive skills with the more formal basic skills used in schools. The success of these experiments is dependent upon the teacher's willingness to take risks and a realization that her own and the student's errors show cognitive work in progress. It is concluded that because music and the arts are non-threatening, they are rich in opportunities for illuminating cognitive research and research in adult learning or teacher development, by being used as a source of mediation between intuitive knowledge and the more formal skills taught in the schools. (CK)

MUSIC AND COGNITIVE RESEARCH: WHERE DO OUR QUESTIONS COME FROM: WHERE DO OUR ANSWERS GO?

Jeanne Bamberger

WP-2 April 1979

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The Division for Study and Research in Education was established at MIT in 1973. It conducts interdisciplinary research in education and is training a new cadre of education researchers, in collaboration with the larger MIT community. By its design, structure and philosophy, the Division stresses innovative collaborative work in which research occurs in tandem with ongoing educational programs at elementary, secondary and college levels. Of particular interest in these contexts is the way in which the formal knowledge represented by school curricula and organized academic disciplines become melded with informal, intuitive knowledge in the mind of the learner. The effect of social context on this process, together with an appreciation for the ways in which these processes are part of the unfolding of individual lives, are emphasized. There is a pronounced interest in the cognitive sciences, in educational innovation and in policy and practice.

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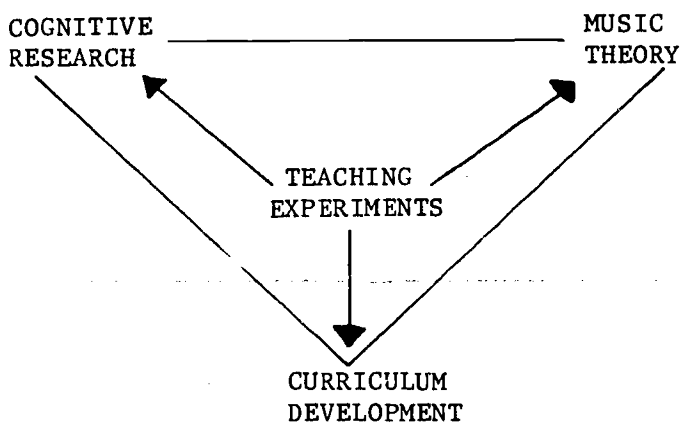
As a newcomer to these meetings and maybe even an interloper in the field of education research, it seems quite inappropriate for me to try to carry out the charge I was given, namely to present an overview, even a critical view of current research in music education. Instead, I would like to engage an issue that appears to be a pervasively nagging one, and one that is much on our minds at M.I.T. as we try to bring our baby Education Division into adolescence. This is the sad awareness that academic research which seems like it should have relevance to the classroom, rarely seems to get there. And this seems as true for research in cognition and learning as for research in the various subject matter domains -- music, for example. In my own experience, the problem often takes the form that what we do when we're being musicians (or artists, or writers, or mathematicians) has little to do with what we teach. Which is to say that our knowledge-in-action seems to lose in translation, translation into formal, sayable, propositions which we, in fact, DO teach. Indeed, the often silent, slow processes, the questions and blind alleys through which we arrive at a proof in mathematics, the solution of a physics problem or one in the performance of a piece of music or in composition, usually remain silent, discarded, as we admire the end result. And then we wonder why our students have trouble DOING what we do.

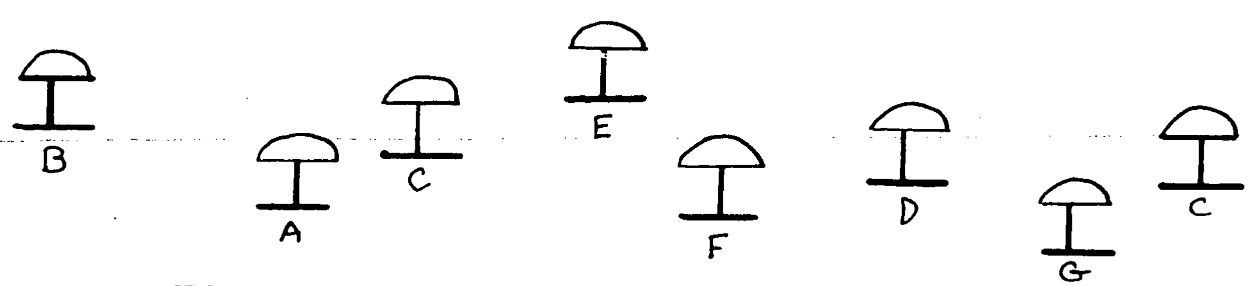
My particular concerns for this incongruence between doing and teaching music theory became sufficiently obsessive to pull me out of the classroom for a while, propelling me down a kind of felt path into such apparently disparate fields as cognitive development, artificial intelligence and computers, epistomology, even into physics and the philosophy of science, only to come back again to a recognition that one needs to do research by teaching. Indeed, I will argue that the way out of the dilemma of the non-congruence between academic research and the classroom is to turn the matter on its head -- to begin with teaching experiments which can, in turn, inform research, for example, in music theory, more traditional experimental research in cognition, and also curriculum development and teacher training. I am suggesting, then, that we should begin with the puzzles that emerge from the phenomena generated by close, interactive, responsive teaching experiments. In fact, I would argue that the central problem in any research, but particularly research that is to be relevant in action, is precisely that of finding the right questions, even finding, "seeing" the "things" which may inhabit a particular situation or region of study. The dynamic pyramid, below, provides a picture of what I mean:



My students and I have carried out such experiments in various contexts and with varying purposes depending on which vector of the above pyramid we are pursuing -- my own work in cognition and musical development, and in music theoretic studies, are examples.[1] But the methodology is now taking the form of an experiment in teacher develo)ment currently being supported by the National Institute of Education, which I am doing together with my colleagues, Eleanor Duckworth and Maggie Cawley. The experiment is designed around the belief that elementary school teachers can learn to carry out teaching experiments in the classroom, they will be in a better position to find the relevant puzzles and to better understand a <u>child's</u> current knowledge-in-action with respect to a given task situation -- his already powerful intuitive strategies for constructing <u>his</u> reality. And, in turn the child will be helped to bridge the gap between this and the ways of knowing expected of him in school. But, we believe, the process must begin with the teachers themselves. They must first learn to reflect on their own everyday knowledge, especially to discover and to trust their informal ways of knowing. At the same time they will be learning that this everyday knowledge may be quite incongruent with the formalisms, the privileged descriptions they have been taught and are, in turn, teaching in school. Thus, we encourage them to learn to find the puzzles that surface in their own thinking as they become involved in simple, but rich task situations. In this way, we argue, they will be learning how to invent situations and to improvise interventions in the classroom. Then they may be able to help the children learn to reflect on and make explicit what it is they know already but can't say.

Unlike more "pure" research situations, where the experimenter withholds interventions in order not to upset the "objective conditions," in teaching experiments, experimenters make use of their subjective awareness and of interventions in order to both test hunches and to teach. Students' responses become the basis for testing the validity of an initial description of the child's current thinking, for forming new hunches and for the subsequent design of new experimental and learning tasks.

Music plays a special role in all of this, both in the initial phase of encouraging teachers to reflect on their own intuitive knowledge, and also later in the classroom. For example, consider an instance of a classroom teaching experiment with an eight-year-old child, Joey. Joey is doing poorly in school and is considered a "troublemaker" by both his teachers and his peers. Chosen as a member of an experimental music class, he is involved in a characteristic experimental task situation. He is given a set of Montessori bells, including the pitches of the C major scale, arranged on the table in a mixed-up array.*

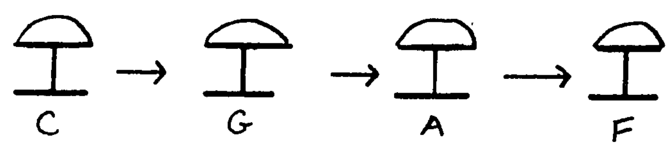


* The bells are not labeled, pitch is selected only by playing them.

The Protocol

T: Can you order the bells from low to high?

(Joey tries all the bells and chooses C to begin with. Then, searching in the array, he adds a G-bell and an A-bell. Playing his "ordering" from the beginning, he tests several more bells, selects the F-bell and stops,



looking up at the teacher.)

T: Is that it?

J: (playing the whole thing, C-G-A-F) Yup.

T: Can you tell me why you chose the last one?

J: Because it sounds good and it makes an ending.

T: (testing a hunch, substitutes a B-bell for Joey's F) How about this one instead? (she plays C-G-A-B)

J: (shaking his head) It's not in order.

T: (going on to test another hunch) Which one would you say makes a higher sound, an elephant or a mouse?

J: An elephant.

T: Why?

J: Because it has a bigger mouth.

T: That's interesting. Well, I would say that this bell (plays B-bell) makes a higher sound than this one (plays low C-bell).

J: Well I would say it was louder.

T: (testing another hunch) Can you start with this bell (low C-bell) and build a tune that goes like this (sings C-major scale)?

(Joey plays the C-bell and then, searching in the mixed array, finds the D-bell. Playing again from the beginning -- C-D -- he searches through the array, each time playing the first two, finds the E-bell and adds it. Continuing in this way, always starting from the beginning of his cumulating bell path, he constructs the "tune" -- i.e., he builds the C-major scale.)

Analysis of the Protocol

Watching Joey's work, the teacher forms a first hypothesis: she hunches that for Joey "to order" means to make a sensible tune. The construction Joey makes (C-G-A-F) does indeed go from low to high at first, but then goes down to F. The result is a kind of "closed shape," a self-contained little "tune." How can she test this hypothesis? She substitutes the B-bell for Joey's F, making an unstable open-ended tune. Joey confirms her hunch by rejecting the new arrangement saying, "It's out of order."

Going on, the teacher tests a second hunch, namely, that Joey has not associated the literal meaning of high (as in "the sky is high up," or "the teacher is higher up than Joey") with its metaphoric use in describing pitch relations. Acting on this hunch, she tries to help him by associating the word with a sound that he knows -- the high squeak of a mouse. But Joey's puzzling response (the <u>elephant</u> makes a higher sound "because his mouth is bigger") results in the <u>teacher</u> learning, not Joey. She is reminded that she cannot assume that <u>her</u> focus (the animals' voices) will be the same as Joey's. Joey, perhaps attending to a cluster of notions -- "high-tall-big" -- focuses on the high-big mouth, not on the voice that comes out of it. The teacher needs to be attentive to the possible mismatches between her descriptions with their underlying assumptions, and Joey's restructuring of her descriptions as a result of <u>his</u> underlying assumptions.

Approaching the issue more directly, now, the teacher <u>names</u> the B-bell, "higher", in contrast to the C-bell. But Joey, remaining true to his representation, rejects the teacher's name and responds with his own -- the B-bell is "louder." For Joey the cluster of related notions evidently includes "high, big, and loud" -- as in "turn up the TV," or "lower your voice."

Finally, the teacher tests her hunch that Joey is quite able to make the aural discriminations named by the words "higher" and "lower" but only as relations within a tune. If he can make a bell construction that matches her sung "figure," (the C scale or the "ordering from low to high") which she now calls a "tune," her hypothesis will be at least tentatively confirmed. Joey succeeds, using a characteristic "felt path" procedure: Always starting from the beginning, he cumulatively builds up the "tune" -- next-next-next -- till it is all there. The teacher's hypothesis is reinforced by Joey's confident attitude and his focused and directed behavior; his intuitive strategies work well within this description of the task.

Implications for Next Steps

The teacher is much closer to a good description of Joey's internal representation of pitch relations. She has also gained some insight into the state of his general cognitive development. But there are still questions. Are the problems with "high" and "low" entirely verbal; does he just need to learn this new meaning for the words? Or are his responses clues to more fundamental cognitive issues? For example, are the properties which he clusters together (high-loud-big) "fused" in his representation, not differentiated? The notions of fusion and conceptual-perceptual differentiation take on more meaning for her. Will she find evidence of such fusions in other subject matter task situations? Are Joey's responses to the notion of "order" and his later construction of the tune-scale, clues that his strategies of representation tend to be "figural" rather than "formal"? That is, does he represent pitches to himself only as functional or "situational" within the figure in which they are embedded, not as properties identified with the "fixed reference" scale? Does he need still to do the cognitive work of constructing the idea of a scale so as to represent to himself its special formal properties, to use the scale as a "fixed reference" with which to name and notate pitches in any tune?

Seeking answers to these questions will guide the teacher as she plans new activities for Joey. Her good description of his ways of knowing and doing in the musical domain will suggest tasks in other domains, as well. The issues that surfaced in this brief protocol -- differentiation of properties, "order" as associated with "figural" meanings in contrast to formal meanings, the description and use of an outside "fixed reference" -- may help to account for Joey's difficulties in math and reading. The teacher will need to test that. Her questions help her to diagnose the possible mismatches between Joey's intuitive strategies and his ways of constructing reality, and those implicit in what is expected of him in school. She is better prepared now to help Joey to do the "cognitive work" involved in building "coordinating schemas" through which he can integrate <u>his</u> basic cognitive skills with the "basic skills" as they are defined and evaluated by school and community.

This example illustrates the kinds of skills involved in teaching experiments, as well as the kind and use of task situations in which these skills can be most productive. Similar experimental situations might involve building familiar tunes with the bells; a group activity like making a description of a recorded piece that the children can use as a "score" to make a new piece; working on a performance of their new piece, or composing a tune, using "tune blocks" instead of individual notes.[2]

Insights and hunches gained in musical situations will, in turn, suggest experiments in other domains. For example, in making descriptions of a piece of music or even a simple, improvised rhythm, children will confront such issues as:

1. Time and how it can be measured;
2. The invention of units of measure and the use of a "fixed reference";
3. How to translate the experience of movement and sound into a static, visual-spatial medium:[3]

What is an element?
How do elements group together to form larger elements?
What is the relation between parts and whole?
How can time become space?

In each teaching experiment which the teacher improvises, she is, as in Joey's story, both testing and teaching; clues to the child's intuitive ways of making sense of the tasks guide her teaching. She asks: What is the child focusing on as the significant features of a thing or a situation; what does he describe as the "same" or as "different"; what, indeed, is a thing, an element; and how does he order the elements, group them together to form his units of description? In turn, she asks, how are the child's descriptions different from those formal descriptions accepted as norms in the school setting; what is the nature of the mismatch; and finally, how can she help him to integrate his own useful, even powerful, ways of knowing with the expectations of school and community?

The term intuitive knowledge has appeared repeatedly in the discussion thus far. It seems important at this point to clarify its meaning as used in the context of teaching experiments and also teacher development. Readers may puzzle over pairing the words "intuitive" and"knowledge." For some they may even seem to present a contradiction. If an individual is said to "use his intuitions," he is thought not to be using his "knowledge." Or if an individual is said to be doing a task "intuitively," then he is not "thinking." How then is it possible to speak of intuitive knowledge or intuitive thinking? The problem arises because intuition is often considered to be, on one hand, casual, inconsistent, even mindless; or on the other hand, mysterious, marvelous, irrational, unlearnable and unteachable, a "gift." Conversely, "knowledge" and "thinking" are considered rigorous, rational, logical, demonstrable in their procedures and rules, possible of formulation in explicit propositions and formal notations, and testable against reality -- facts, as in a body of knowledge or a systematic theory. We find, for example, the following comments on the "gift" of teaching:[4]

> For generations, gifted teachers -- even in the absence of clear intellectual guidelines for instruction -- have followed their intuitive inclinations in effectively guiding their teaching and their children's learning. The rare artist of a teacher may never need intellectual guidance and may, indeed, suffer from it. But the demands of education are too important, too difficult, and too massive to allow us to rely on rare gifts and unexplicated intuition ... Intuition alone seems both insufficient to the magnitude of the present demands and poorly suited to building cumulative knowledge about instruction.

Here we see "knowledge" set in opposition to the "intuition" of the "artist of a teacher" which is a "gift" but not sufficient to the "demands of education." Given these apparently opposite characteristics of knowledge as compared with intuition, what can be meant by conjoining them? The conjunction rests on previous experimental work done in the Division for Study and Research in Education at M.I.T. which demonstrates that the internal representations associated with intuitive knowledge, even with respect to specific subject matters (music, physics, math) are consistent, rule-driven, powerful, testable against experience and possible of rigorous formulation.[5] However, internal rules of this knowledge, the implicit strategies for constructing reality, are often significantly different from those formulated in textbooks or in formal theories pertaining to the same subject matter. But intuitive knowledge cannot simply be dismissed as wrong. On the contrary, in the domain of music, physics and math, for example, the intuitive knowledge of children and of naive adults appears to share aspects of knowledge-in-action used by experts in these fields.[6] But as suggested earlier, the action knowledge which experts make use of in everyday work is often not included in their public, theoretical writings or in their teaching.

We must ask, then, what about the incongruences between intuitive ways of knowing and doing and formal descriptions of knowledge? Are they kept separate, one private, the other public? Or can they be mapped one onto the other; and if so, how does one learn to make such coordinations?[7] To take a familiar example, how do we learn to coordinate the experience of a walk through the streets of a city which takes place through time and in three-dimensional space, with the static description of that path as captured in the two-dimensional space of a coordinate map? Or, how do we (if we do) learn to coordinate our abilities to apply a force to an object so as to move it appropriately, with formal descriptions of force and acceleration like F = MA?

These have become central questions in the context of our experiment in teacher development. Let us assume that a teacher, like most individuals, makes use of cognitive strategies embedded in her actions -- her particular understandings, ways of setting and solving problems in any given situation -- which are different from and not mapped onto the representations she has been taught and is, in turn, teaching in school. She is then in the uncomfortable (and perhaps often untenable) position of being stuck with one acceptable "right answer" in her classroom, an answer which, in a profound sense, she does not believe in. At the same time, she leaves outside of the classroom (perhaps with embarrassment) as inappropriate, her powerful reservoir of intuitive strategies; strategies for making sense, let's say, of space, time or number, her intuitive ways of differentiating, of determining same and different, or of finding and building patterns. It is not surprising, then, that she has difficulty making contact with and understanding her students' intuitive ways of constructing coherence. Those students who continuously fail to come up with the "right answer," who are labeled "unable to learn," remain a puzzle.

This formulation leads to three hypotheses which we are testing in our current seminar:

1. Teachers can learn to practice skills of cognitive self-reflection. That is, they can learn to surface and make explicit their own intuitive knowledge as it relates to specific subject matters and to their teaching practice.

2. Once a teacher has gained insight into her own knowledge, she can begin to learn how to coordinate it with the privileged descriptions of subject matters that she is expected to teach in school.

3. These skills can serve as a powerful resource for coming in contact

with, understanding, and making good descriptions of her students' intuitive ways of constructing coherence. In turn, they will help her identify the particular ways in which the child's intuitive representations are incongruent with more formal descriptions so that she can help him, through careful interventions, to coordinate his ways of knowing with those expected of him in school.

While we are gaining some evidence that tends to confirm these hypotheses, the success of the program seems to rest most intimately on the willingness of teachers to take cognitive risks. For to learn in the ways described above, involves individuals in moments or periods of cognitive disequilibrium as they come to see things in a new way. The degree to which teachers are willing to risk passing through these periods when they may find their initial intuitions in disarray, is a central question in the effectiveness of the program.

In the light of this discussion of intuitive knowing, the stance towards error in teaching experiments gains special importance. Certain kinds of errors are often clues to the incongruences between an individual's current state of intuitive knowledge and the particular knowledge inherent in the descriptions and notations for which he is held responsible by the schools and by society. Piaget, for example, points quite explicitly to the importance of "systematic errors" associated with cognitive disequilibrium and the learning which may follow:[8]

> It can easily happen that the equilibrium between assimilation and accommodation takes forms that are not quite adequate, so that adaptive effort results in systematic errors (italics are Piaget's). Such systematic errors are found at all levels of the hierarchy of behavior ... The progress of knowledge requires a perceptual reformulation of previous points of view by a process which moves backwards as well as forwards, continually correcting both the initial systematic errors and those arising along the way ... For science to shift from a geocentric to a heliocentric perspective required a gigantic feat of decentring. But the same kind of process can be seen in the small child, a process in which he must shift a given cognitive perspective.

Thus, an important aspect of both the teachers' cognitive self-reflection and later her teaching experiments with children, will be to take a positive stance toward her own and her students' errors. As Piaget suggests, in coordinating an initial state of intuitive knowing with a later state, systematic errors occur which reflect the cognitive work involved in restructuring a "previous point of view." One, quite literally, comes to <u>see</u> in a new way. Just such "shifts in cognitive perspective" constitute significant learning; anything short of it too easily leads to ritual incantations or to failure to learn altogether.

Music is playing a special role in the seminar just as it does in teaching experiments in the classroom. Music is a fresh and non-threatening domain, for many not yet encumbered with the garb of learned formal descriptions and societal expectations. And yet, it is a domain in which nearly everyone has experience. For example, most people can make sense of a tune, clap a simple rhythm or recognize a piece they have heard before. While they may insist that they "don't know anything about music," they indeed are making use of powerful intuitive cognitive strategies as they construct coherence and respond to the music around them.

As teachers participate in task situations such as Joey's, these intuitive strategies surface. Because they are still free of learned formalisms, their descriptions and constructions will remain close to immediate experience. At the same time, these spontaneous descriptions, as in the Joey story, are revealing possible mismatches between the participants' intuitive strategies and those they may be expected to teach in their classrooms. Like Joey, the teachers are beginning to confront these incongruences in representation and to do the cognitive work required to coordinate them with more formal descriptions.

In this way music contrasts with other domains more central in the school curriculum (math, science) where the knowledge one holds is on one hand, held tacitly, and on the other embedded in formal notations and descriptions. These formalisms are often difficult to tear away from the underlying strategies one uses spontaneously in making sense of the world. One tends to "see" one's own knowledge through the "filters" imposed by formal instruction. In addition, an individual is hesitant to take the cognitive risks involved in confronting mismatches between the formal knowledge she has learned to teach and the intuitive knowledge she actually uses in everyday life. But as the teachers learn to confront these issues in the less vulnerable domain of music, they are gaining the courage to do so in other domains, as well. Indeed, the underlying basic skills which are triggered in musical tasks are leading them to discover similar intuitive strategies operating in other domains such as physics and math.

Let me turn, now, to some examples of the seven elementary school teachers' work in our current seminar. In one music task situation each group of two or three teachers was given a collection of seven Montessori bells selected by us so that it would be difficult to build a tune that sounded familiar -- i.e., the set did not make up a simple major scale. Their task was to construct a tune that made sense and then to make as rich a description of it as they could. As a result of the particular choice of bells, all of the groups expressed the problem of working with some bells that "didn't fit." That this was an expressed problem demonstrated to us and to the teachers that they already had well-defined internal "rules" for what did "fit" and, indeed for what might be a "sensible tune." For many, this came as a surprise since all of them claimed that "they didn't know anything about music." Further, all of the groups, after considerable experimentation, were able, using all the bells, to build tunes that they found acceptable. The process of making descriptions of these tunes turned out to be quite literally one of reflecting on their knowledge-in-action. That is, having built a tune, through considerable experimentation, through knowledge-in-action (arranging and rearranging the bells, trying all kinds of combinations and orderings), they were able, later, to describe what made the tune make sense to them -- i.e., to discover the knowing behind their actions. For example, they described their bases for making decisions, what and why they accepted or rejected a particular possibility, as well as defining the process of searching for a particular kind of solution, much as, I believe, a musician might when he is doing, but not teaching. In this process, they were thrust into reflecting also on their uses of language and number. Numbers, for example, were often understood and used in several different ways -- as line numbers in a set of instructions, as a number indicating the "times" you hit a bell (cardinal number), or as the name of a bell according to its place in the set-up row (ordinal number). It was surprising for the teachers to discover that they could spontaneously understand and act in response to those different uses of number even though their distinction has not been made explicit before.

It was in the process of making these descriptions that the most interesting issues arose. Just which elements of their tunes were singled out for naming, on what level of detail, and which elements were given the same name, which different, were all issues that needed to be confronted in a new and fresh way. In this process, assumptions concerning apparent knowledge in other domains were brought into question. For example, how could you say how long a note or a phrase lasted, how could you measure time (were the two parts of a tune or a part of any structure, or did the names (numbers) given to bells mean order of occurrence in the tune, or an arrangement from low to high? How could you tell high and low, anyhow? Most of these questions were seriously engaged during the working sessions, but interestingly, the final descriptions of the tunes were quite terse. In fact, the teachers (like their teachers) seemed to deny the struggles they went through, especially the "mistakes," which were left out of their final descriptions. Through discussion of the video-taped working sessions, the teachers came to see the importance of these "mistakes" as a source of learning, as something to attend to, rather than to exclude.

Perhaps most surprising, the groups discovered that all of their tunes had some characteristics in common, even though, on the surface they seemed quite different from one another. For example, all the tunes were symmetrical --

i.e., each tune consisted of several phrases, and within any one tune, each phrase had the same number of beats. The problem of how to determine if two phrases were indeed symmetrical, seemed a difficult one -- to find the underlying beat and to believe that counting it would accurately measure time, seemed unconvincing to most. Using the clock as a measuring tool seemed much more "accurate" and reliable. This is a good example of the group's reluctance to believe in their own experience, especially their own direct observations. They seem to perfer to trust "calibrated" tools like clocks and rulers, outside measures, rather than their own senses. All the tunes were similar, also in that they ended in a way that sounded "ended." In most cases, in fact, the groups had searched quite explicitly for, and then found some way of arriving at resolution. These were all clear examples, again, of the group's working, internal models of musical coherence. They could see their tune constructing, then, as a process of "matching" these models and, to some extent, their reflective descriptions served to make these intuitive models of musical coherence explicit.

As in our other teaching experiments, the seminar is also generating intriguing puzzles for future research -- in this case, research in adult learning and curriculum. For example, the knowledge evidenced in the decision-making of construction and, indeed, in the rather complex completed tunes themselves, is quite disparate both in degree and in kind from the categories used traditionally in teaching music. One tune, for instance, included a change in key which was carried out in a very sophisticated fashion.

To make a formal description of the tune requires theoretical training of the kind you might expect to get in an advanced harmony class. In turn, the same tune includes shifts in rhythm which would be difficult for a novice student to either read or notate. In another instance, one group rejected several given bells as "not fitting" and chose a new bell as "necessary for completing the tune." In fact, the bell they searched for and finally chose made explicit a principle in music theory which has been put forth only recently by those who are working in the field.[9] While the teachers' work provides beautiful experimental evidence for such music-theoretic principles, it poses the question of just where one should begin in teaching. At the same time it brings into question the thorny theoretical question, just what are the "primitive" elements of music. The traditional language of musical description takes as its primitives, discrete "objects" -- individual pitches and individual durations, for example -- which are then aggregated to form larger relations. The teachers, as musical novices, clearly demonstrated that their knowledge-in-action begins at a much different level of relations. On the other hand, principles involving time measurement -- beat and meter -- with which music theory and performance instruction often begins, seemed not easily accessible to the group. This raises again the question of the gap between theory, instruction, and intuitive performance. As resported in a recent technical report on the project, we are finding that the issue is as significant in adult learning as in child learning, and as true in other domains as it is in music:[10]

> For example, contrary to many interpreters of Piaget who see as central the idea that children's thinking is different from adults', our hunch is that adult learning is astonishingly similar to children's. While ideas are forming at any age and at any level, all of us slip back and forth between moments of clarity and uncertainty, intuitions and formalisms, coherence and incoherence. More specifically, our notion is that in areas which are new to them, everyone responds in ways which are normally thought to be characteristically children's ways of responding. Sorting out the new realm may take less time for adults, but it is no less tortuous. Material from the seminar suggests that this hunch is right. It is generating rich data that enables us to study the evolution of adult ideas in complex domains.
>
> The seminar has allowed us to look at the teachers' thinking at three major levels and in three different domains: their thinking about the prima faciae subject matter (music, physics, math); their thinking about their own learning; and their thinking about teaching. In all three realms, we have occasion to take note of assumptions, uncertainties, new confusions, construction of new perspectives and evolution of new assumptions.

We have occasion to note these because of our own assumptions about teaching experiments -- namely, that it is through looking at the ideas that one has, and seeing where they lead, that one's ideas develop further (as opposed to the assumptions of much teaching -- namely, that ideas that one has are to be exorcised and neatly replaced). Thus, at the very center of our seminar is the exploration of the ideas these teachers have and the ways they evolve.

In one task situation, the teachers' interest in measuring time in their tunes evolved into some experiments in the construction of "time-machines." When asked to find a way to measure the length of a tune (without using the clock), all worked hard to create single-purpose measuring devices -- something that took exactly as long as the portion of the piece to be measured. Nobody spontaneously tried to find a repeatable unit of measure and that idea evolved only slowly. This bears an obvious similarity to the way children's notions develop with respect to measuring: when children are asked to build a tower as high as a model tower, the first implement they choose to use other than reference points on their own bodies, is a stick that is exactly the right length -- a single purpose measuring machine. In another example, when comparing the number of swings made in the same time by two pendulums of different lengths, teachers spent considerable time trying to make sense of the absolute differences they found in the number of swings -- just as 10-year-olds do -- rather than looking for ratios.

Later, these experiments in measuring time developed into experiments with time and motion. A schematic drawing of the distance covered by a rolling ball, in fixed intervals of time, led to considerable discussion and argument before agreement was reached on whether it is greater distance between marks or greater number of time marks per distance, which indicates greater speed. This reproduces in almost every detail Piaget's work on syncretism in quantitative comparisons, especially in this space-time-speed realm. It is also easy to recognize in ourselves how hard it is to be sure one has it right.

The figuring out of tunes and time-machines is one level of thinking; this level of "figuring out" becomes the materials for the next level -- thinking about what goes on when one figures something out. This takes a longer time, of course -- the ideas are more complicated, and the data are less neat and less numerous. Nonetheless, we are seeing some developments. For example, watching a videotape of a boy building a tune with the bells, the original assumption on the part of all the members of the group was that going back to the beginning each time -- starting the tune over -- was a sign of some kind of inadequacy. It was only when they themselves tried to build the same tune and found that they had to keep starting over from the beginning that they started to question that assumption. The context for each new bell needed to be created by the tune itself. They managed to construct a new way of looking at what was involved in the task and to appreciate the merits of starting over from the beginning each time.

The general cognitive theme here -- the influence of totalities as opposed to elements -- is a complicated idea to construct. But the same theme is appearing in different guises throughout the seminar sessions and its construction keeps getting more solid.

With all of this in mind, I would like to return to more specificially musical issues and to the classroom in order to discuss the role of materials in teaching experiments. In the process I hope to make the connection between teaching experiments and research more explicit -- to bring my dynamic pyramid to life. Consider first, a more typical music task: A child is given a color-coded xylophone, felt-board staff, and moveable notes. Each color-coded xylophone key names a pitch, each pitch-name has a place on the felt-board staff. The child plays a familiar tune on the xylophone. Then, matching each key-color with its place-name on the staff, she puts each movable note on the appropriate line or in the appropriate space. The task is completed when the child has correctly made this particular description of the familiar tune -- a description in staff notation. It is this description which the materials are designed to teach. It is the child's ability to make <u>this</u> description which is evaluated as her mastery of the materials and perhaps even as mastery of this basic skill. And with this idea, we move along the vector towards research into mental representation, its relation to description and symbolization.

For example, these materials, like others (Cuisenaire rods, number lines) carry an implicit assumption that a particular description (the one favored by a community of users) is <u>the</u> description for that domain. Competence with the favored description is seen as the same as competence (even knowledge) in the domain. But, in fact, there are many viable descriptions of (in this case) a tune. Each description captures different features and relations of those possible. Given a set of materials and a task, we can ask: What has the child learned when he has learned the privileged description of a tune? What do the names name in the child's own experience of the tune? What would the child's spontaneous description of the tune look like -- whether in words, in constructions, or in drawings? Are the two sets of descriptions different, and if so, do they each carry with them different, but still viable, ways of representing the tune? It seems unlikely, for example, that the thing named "G" is always the same in Joey's internal representation of the tune. His apparently "figural" strategies (fusing of properties, his tune-scale) will give the pitch a different meaning, even a different name, as a result of its function (beginning, ending) or temporal position (before, after) in the context of a tune. While Joey might successfully master this set of materials, he may in fact have learned a "closed-system vocabulary." That is, he may have learned the referents for names included in the staff notation description (name and place on the staff and instrument), but these names refer only to elements within the system itself. If all the G's are not the same in Joey's own experience of the tune, in his internal representation, then the name, G, refers only to its meaning within the system that names it; it does not refer to a functioning element in his representation of the tune. This is a researchable question which might involve not only Joey but others as well. When are children spontaneously translating their experience into a description that is significantly different from one that they are given; when is "learning" the given description learning a "closed-system vocabulary"?

Another research question might be: are the materials designed to teach staff notation then useless? Should children not be bothered with staff notation since it may be incongruent with their own effective ways of constructing meaning? This seems unlikely since staff notation is a privileged description necessary for musical communication and learning and remarkably powerful in its way. Can teaching experiments then make use of such materials together with skillful observation and reflection to help a child like Joey do the cognitive work required to make an initially closed-system vocabulary an "open-system vocabulary"? Can the privileged description, initially incongruent with the child's, teach? Can names referring to things not yet in his experience trigger the child's awareness of elements and relations? For example, the name "high" names a particular relational property which is apparently fused in Joey's representation with big and loud. Naming this particular relational property, together with invention of tasks which separate out properties within the research and the classroom might be enhanced by turning the direction of this movement around. That is, instead of attempting to apply research in cognition, in learning, and in various subject matters, after-the-fact, to the classroom, that we might begin instead with information-rich teaching experiments -- with the puzzles, questions, and hunches generated by close observation and responsive interventions, using them to inform and guide the design of more constrained formal research. I have, in what followed, tried to give you some inkling into how that might work and especially to provide a kind of framework for research in musical development, music theory, and music education.

However, in the process it may seem that I have neglected my responsibilities to the place of music in it. Indeed, it may appear that I have used (or maybe abused) music, simply to illustrate this other enterprise. But my intentions and commitments run deeper than that. The role of the arts, and music in particular, is central to my argument about the relations between research and practice. I have tried not only to include ways in which teaching experiments of the sort I have described can provide direction for research in music theory and music education, in particular, but to go beyond that to make the argument that music, if taken seriously, can be a remarkably rich domain for illuminating cognitive research, research in adult learning, and in teacher development.

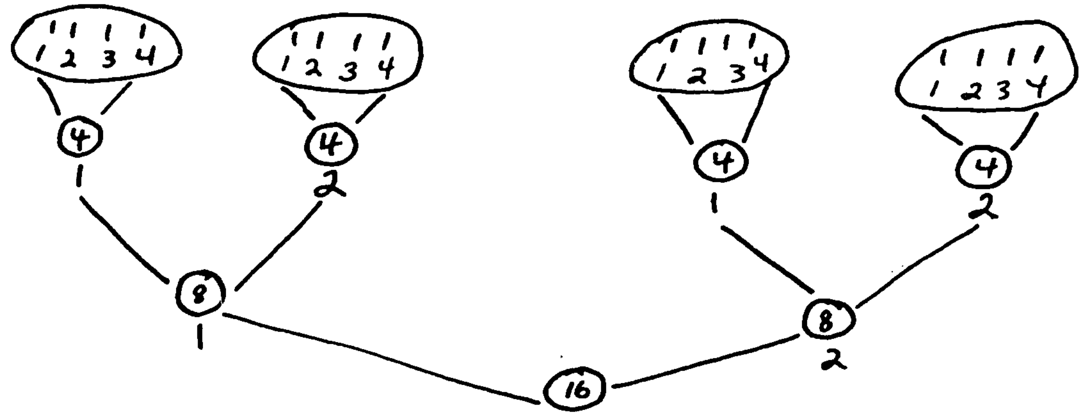
In addition, I would like to argue that the arts, and again music in particular, can assume a primary role in the classroom if it is seen as a source of mediation between intuitive experience and the privileged languages taught and spoken in the schools. On this view, justification for the arts in the classrooms gains vigor. But, I have also intimated that this argument will only work if we pursue our work in a number of related domains, rigorously and in an interactive way. However, this program of enterprises may mean giving up something, as well. We may find it necessary to give up an instrumental approach where education research is seen as a process of designing instruments which will achieve specified goals and objectives and, instead, to experiment, "invent and develop learning systems ... capable of bringing about their own continuing transformation."[11]

NOTES

1. See, for example, J. Bamberger, "Cognitive Structuring in the Apprehension and Description of Simple Rhythms," (in press, 1979); C. Hildebrandt and J. Bamberger, "Claps and Gaps," (in press, 1979); and J. Bamberger, "Intuitive and Formal Musical Knowing: Parables of Cognitive Dissonance," (1978).

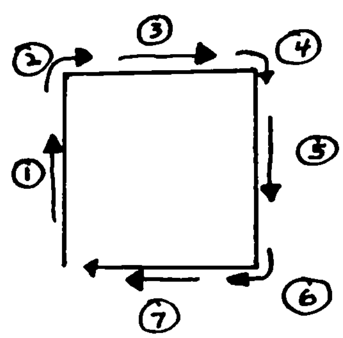
2. "Tune blocks" refer to the small motive or meaningful structural "chunks" which together make up a melody. For example, the first part of <u>Three Blind Mice</u> is made up of two tune blocks: "three blind mice" and "see how they run" each of which is repeated twice. The term also describes a game which can be played using the LOGO computer music system. Each tune block is actually a computer procedure that, on command, instantly plays the requested small motive on the computer-controlled "music box." <u>Three Blind Mice</u>, for example, is made up of four blocks, named 'Mice 1 - Mice 2 - Mice 3 - Mice 4. The game is to arrange the four tune blocks so that they make up the whole tune. In this way, students can experiment with tune construction on the structural level rather than on the more difficult note-to-note level. In another version of the game, students are given unfamiliar tune blocks with which they can make up their own tunes. (See Bamberger, 1977, for a more complete description of the game and its teaching and research possibilities.)

3. The issue of making descriptions of experience both within a single medium (improvising a new piece from an old piece) and across media (translating something heard into a verbal description or into a picture or diagram in "paper space") is a particularly powerful tool for both diagnosis and teaching. For example, experiments may reveal that a child represents a whole rhythmic figure as "an element" in his improvised drum piece. Further experiments might illuminate the possibility that he also describes a whole word or even a phrase as "an element" in spoken discourse. If so, he will clearly have trouble coordinating <u>his</u> representation with the descriptions captured in music notation or in written language. The mismatch between the child's representation and that of the accepted encoding might suggest experiments which will encourage more fine-grained descriptions where each "hit" in his rhythmic figure becomes an element. He will then need to confront the question of relations among levels of grouping -- how do individual hits (or letters) group together to form figures (or words), how do these group together to form phrases? Such questions also underlie basic arithmetic operations. For example, in multiplication the child must learn to group together the lowest level unit of description (1's) which he initially counts singly -- 1-2-3-4 -- into one higher level unit of description named "4." He is then prepared to understand the operation "2 times 4" as forming another single aggregate named 8, etc.:

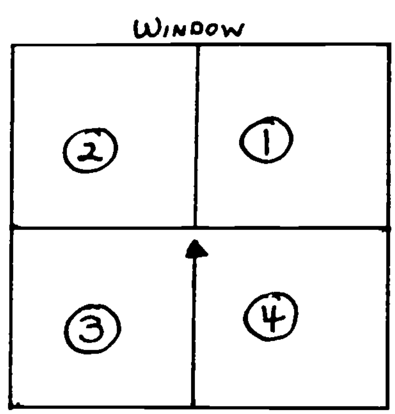


These are questions which involve cumulative descriptions (next-next-next, as in Joey's felt-path tune construction) as contrasted with an aggregated description where the sequential occurence of elements becomes a single "event" as if experienced all at once. This difference in description suggests experiments with naming where a sequence or even arbitrary individual elements or actions is labeled as a single thing and then embedded in new aggregates. Such experiments are characteristic of the child's experiments in the LOGO computer environment where he learns to give a single name to a sequence of computer actions (a computer procedure) and then to use this aggregated sequence of actions as a sub-procedure along with others to make up a single super-procedure:

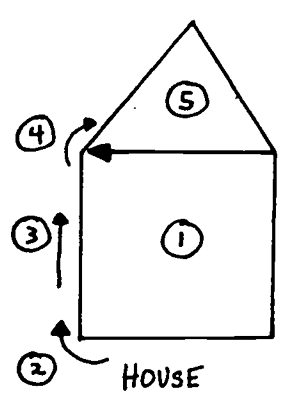
To Square
1 Forward 100
2 Right
3 Forward 100
4 Right 90
5 Forward 100
6 Right 90
7 Forward 100
END



To Window
1 Square
2 Square
3 Square
4 Square
END



To House
1 Square
2 Right 90
3 Forward 100
4 Right 30
5 Triangle
END



```
To Triangle
1 Forward 100
2 Right 120
3 Forward 100
4 Right 120
5 Forward 100
END
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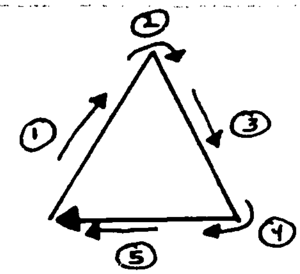

4. G. Lesser, (ed.) Psychology and Educational Practice, p. 3.

5. See A. diSessa, "On Learnable Representations of Knowledge," (1977) for a discussion of intuitive knowledge among physicists.

6. For a discussion of the similarities between children's and expert's intuitive knowledge with respect to music, see J. Bamberger "Intuitive and Formal Musical Knowing: Parables of Cognitive Dissonance," (1978).

7. Our current research into intuitive knowing suggests that the intuitive knowledge of an expert includes, in fact, the important cognitive actions involved in coordinating his action-knowledge of the domain with the formal descriptions associated with it. In contrast, less skilled individuals tend to hold these representations in isolation from one another, typically using one in the context of school learning and examinations, the other in everyday life. We find, for example, that this is a typical issue for freshmen physics students at M.I.T. where their effectiveness may eventually hang on their ability to make these coordinations.

8. From Piaget's "Comments" in Vygotsky's Thought and Language, (1962), pp. 2-3.

9. See, for example, Narmour, E., Beyond Schenkerism, University of Chicago Press, Chicago, 1977; and Lerdahl, F. and Jackendoff, R., A Formal Theory of Tonal Music, M.I.T. Press, 1980.

10. The following section on adult learning is taken from the "Quarterly Report to the National Institute of Education," February 1979, prepared by Jeanne Bamberger, Maggie Cawley, and Eleanor Duckworth.

11. Donald A. Schön, Beyond the Stable State, p. 30.

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