THE BIOMECHANICS BODY OF KNOWLEDGE

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INTRODUCTION

Thank you for your presence at this conference and at this presentation. I will infer from your attendance that you care about the learning and teaching of biomechanics. In that regard, I will take you as kindred spirits. Moreover, I am fairly certain that you are geniuses – more about that later. Given that I view you as kindred spirits and geniuses, I would like to have you as allies. So, please remember, whenever I say something that conflicts with your cherished beliefs, the word is allies – not enemies.

Today I would like for us to consider the biomechanics body of knowledge. By biomechanics I will be referring primarily to human movement biomechanics as it might be practiced in departments of physical education or kinesiology. I will be using the term body in both literal and figurative ways. As for knowledge, we will examine several perspectives. In particular, those perspectives can be framed with the following questions:

How is our body of knowledge conceived? What aspects of our body are prominent when viewed by ourselves, our students, our colleagues, and our constituents? How is our body of knowledge communicated to and consumed by our students? How is our body of knowledge critiqued; what does it look like when the procedures of critical theory are applied? And finally, how is our body of knowledge constructed?

CONCEPTIONS OF KNOWLEDGE

Let us begin with how our biomechanics body of knowledge is conceived by the world at large. In my opinion, our "body" is essentially invisible to the person on the street. Of course, we have more name recognition than we used to, but most people simply do not know who we are or what we do. In this regard I think the position of biomechanics can be compared to that of economics. To make this point, I will paraphrase from a recent valedictory by an economics graduate (Semitsu, 1996) entitled "Why you can't find any listings for economists in today's Yellow Pages."

> My fellow graduates in biomechanics, once we receive our diplomas, we switch from the status of student to the status of unemployed. Fortunately, when we stand in an unemployment line, we should have a much better understanding of the line of gravity during stance. Unfortunately, we have additional problems to deal

> with. Along with a tight job market, we have the burden of explaining what biomechanics majors are supposed to do after graduation.
>
> After all, “biomechanist” is not listed in the Yellow Pages. Nobody ever says, “Honey, you know what we need to fix this problem? We need a good biomechanist.” Nobody needs a good biomechanist in the middle of the night.
>
> Part of the problem is that we biomechanists can never agree on anything. We are so famous for disagreeing with one another that many people think astrology is a more exact science than biomechanics. Certainly, most people follow their horoscopes more closely than our predictions.
>
> Americans do not listen to biomechanists because we do not speak to them. The world wants more astrologers than biomechanists because astrologists tune in to everyday people. Even presidents tune in to astrologists more than biomechanists.
>
> The problem is not just that biomechanists don't speak the same language as ordinary people, nor is it just media neglect. Part of the problem is our narrowing vision. We perform studies of the correlations between things that do not matter instead of between things that do matter.
>
> We need new ways to measure the things that matter. We need to change the rules. We graduates need to reclaim our field and ground it in society so that as future biomechanists, we provide a service to all America. We must take democracy to mean social equity in terms of skillful and safe movement. Once we do this, my fellow graduates, maybe we'll finally be listed under “biomechanist” in the Yellow Pages. (p. B9)

For the record, none of the largest cities in America has listings for biomechanists in the Yellow Pages. And the image of George Bush batting is evidence that presidents could pay more attention to biomechanists.

Well, if the world at large sees the body of biomechanics as invisible, how do our colleagues see biomechanics? Our critical colleagues call us “a camera without a question.” We are seen as a tool but not a topic. We are seen as being atheoretical. We even see ourselves as being atheoretical. At the third national teaching conference, Susan Hall (1991, p. 113) stated that “no prominent, widely referenced, broad-based theories have been advanced by biomechanists from within the field of kinesiology.”

So how does the biomechanics body look to biomechanics researchers? Most of us tend to depict the body as a stick figure. Certainly I am among the guilty, as I displayed Figure 1 during a recent research presentation (Hudson, 1997). What would a scholar with a grounding in critical theory say about this body? It could be described as static, segmented, thin, hair-brained, and, with the hands cut off, unlikely to connect with others. How many of these descriptors of our figurative body of knowledge apply as well to our literal body of knowledge?

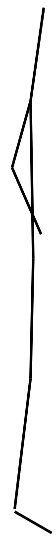

Figure 1. The body as a stick figure.

How is our body of knowledge conceived by teachers? Almost fifty years ago, Katherine Wells (1950, p. 1) said that "Kinesiology . . . is not a true science because its laws and principles are borrowed . . . . Its unique contribution is that it selects from other sciences those principles which are pertinent to human motion and systematizes their application."

Let us look at what we have borrowed for our basic biomechanics classes. Much of our muscular foundation – that is, the names, locations, and actions of muscles – was known at the time of daVinci about 500 years ago. We use a mathematical system – Descartes' x-y coordinates – that has been available for about 400 years. And our mechanical foundation – Newton's laws – has been around for about 300 years. Of course, we have added knowledge to these areas in the last few hundred years, but we are still much more likely to use classical science than contemporary sub-cellular and sub-atomic science. What does this have to say about our body of knowledge? To what extent are we willing to consider this centuries-old foundation material to be <u>our</u> body of knowledge?

If we do not want to take our primary identity as scavengers of other bodies, perhaps we should pay closer attention to the second part of the Wells (1950) quote. She believed that we synthesize and systematize pertinent information for its application to movement. Indeed, as Wells says, we are unique in this particular integration and application. That suggests to me that our body of knowledge might be focused on this area rather than on what we borrow.

While we are thinking about how biomechanics teachers conceive of our body of knowledge, I would like to reference three individuals: First, Kay Luttgens registered for the first national teaching conference in 1977 because she was looking for the “goodest” of kinesiology courses. (1978, p. 45) But, to her distress, she was assigned to bring that which she was seeking. Of course, that was a relief for the rest of us who also wanted to be told what was the “goodest” of kinesiology courses. Today, we might refer to that attitude as passive learning.

The second individual is Shirl Hoffman. At the second teaching conference in 1984, he claimed that “those of us who teach undergraduate kinesiology are lost.” (p. 67) In particular, he felt that we lacked “insight into how a knowledge of mechanics may help teachers and coaches make clinical decisions.” (p. 68) And, we “have been delinquent in designing programs to train students to see movement.” (p. 69) I think his points are still valid.

The third individual is a fledgling biomechanist searching for her first teaching position. She was asked to present a lesson to a basic biomechanics class; her only guideline was that her lesson needed to be “applied.” In essence, she had the opportunity to show off her primo stuff. Her solution was to lecture for an hour on how the body was like a wheel barrow. The students were not impressed. Neither was I.

Perhaps I am being too harsh on the young teacher. After all, our original guidelines and standards (NASPE Kinesiology Academy, 1980) include 13 specific exit competencies in anatomy and 18 in mechanics. But, we only have four general competencies, listed in Table 1, in our applied section. Are we expecting the impossible of our students and young teachers when we presume that they will use these guidelines to “demonstrate a systematic approach to an analysis and to complete it with a basic level of competence”? (p. 21)

How do students feel about all this? According to research by Shirl Hoffman (1984), former students perceive our application guidelines as among the most “useful . . . in the real world.” (p. 68) However, they receive so little training in these competencies that they “aren't very good” at clinical diagnosis. (p. 69) Instead, most of their training comes in anatomy and mechanics. Also, many of Hoffman's former students confessed that they did not understand what our competency statements meant.

Table 1
Exit Competencies in Application of Kinesiological Concepts

1. Observe and describe a movement technique accurately.
2. Determine the anatomical and mechanical factors basic to . . . an observed movement.
3. Evaluate the suitability of a performer's technique with reference to the task at hand.
4. Identify those factors which limit performance and establish a priority for change.

So, our students may have the conception of our body of knowledge depicted in Figure 2. Can't you hear them saying, “Well, there's the muscle stuff . . . There's the mechanical stuff . . . It's sort of clunky. And not much of this is connected to anything else.”

In sum, our constituents seem to conceive of our body of knowledge as invisible, atheoretical, ancient, and irrelevant. And we want to conceive of our body of knowledge as analytical, integrated, applicable, and important. This could be a problem.

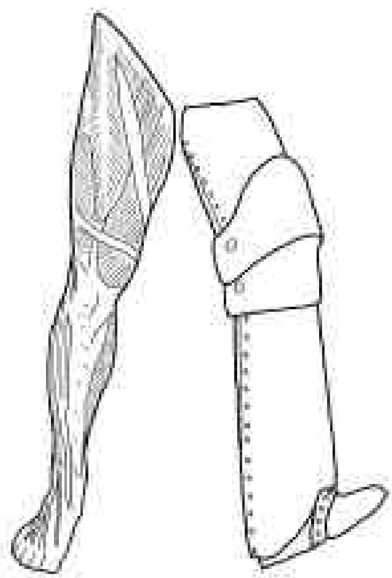

Figure 2. Students' conception of our “body” of knowledge.

COMMUNICATION OF KNOWLEDGE

Now let us consider how we communicate or articulate our body of knowledge. At issue are both the organization and the transmission of information. To use a sound bite, it appears that we organize our body of knowledge around one question: How do humans move? The content of both our textbooks and our research seems oriented to this question: In our instructional literature, we distinguish the difference between flexion and extension, and we detail how Newton's laws apply to earth-bound athletes. And given that our investigations are almost entirely descriptive, the question "how do humans move?" dominates our research literature. In the coming paragraphs I will explain why I think this how-do-humans-move orientation is problematic.

As for the transmission of information, we are often guilty of using the funnel-brain approach. That is, we treat our students like empty vessels and bombard them with pearls of wisdom (see Figure 3a). One way that we do this is by emphasizing low-to-intermediate level thinking skills in our students. If we apply Bloom's (1956) taxonomy of instructional objectives (listed as the enumerated descriptions in Table 2) to our guidelines (NASPE Kinesiology Academy, 1980), we see that many of our competencies can be handled at the knowledge and comprehension levels. Of course, given the hierarchical nature of learning, a certain amount of this may be necessary. We stress application, the third of six levels in the Bloom model, when we cover the use of facts and principles. By the way, this is not what I think we mean by "application" in our guidelines. Perhaps because of the emphasis on quantitative analysis in our graduate training, we may include some of these intermediate-level experiences in our classes. Rarely, in my opinion, do we include much use of the higher order thinking skills of synthesis and evaluation. Why?

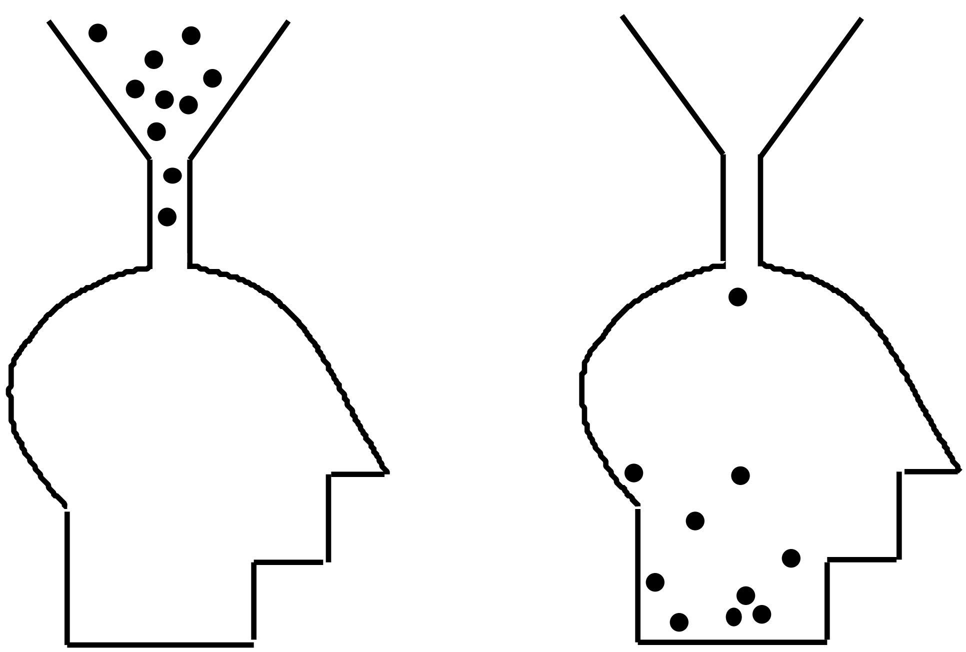

Figure 3. The funnel approach to filling our students' minds (left) and the Teflon brain syndrome (right).

Do our guidelines not specify that our students should be able to "evaluate the suitability of a performer's technique" and "establish a priority for change"? Are these not evaluation-level tasks? Is it because synthesis and evaluation are relatively incompatible with the funnel-brain model, and we are committed to it?

There are some likely reasons why we slight the higher order thinking processes in our classes, and the first has to do with our students' epistemology. To develop this point I will briefly review two epistemological schemes. As you may know, epistemology refers to the ways people view reality and draw conclusions about truth, knowledge, and authority. According to Perry (1970), these perspectives are generally hierarchical and range from less to more sophisticated. Our students can fit into any of the following four epistemological positions:

Table 2
<u>Bloom's Taxonomy and Questions</u>

1. Knowledge – identification and recall of information
   - Who, what, where, when, how _____?
   - Describe _____.
2. Comprehension – organization and selection of facts and ideas
   - What is the main idea of _____?
   - Retell _____ in your own words.
3. Application – use of facts, rules, principles

- How is _____ an example of _____?
- How is _____ related to _____?

4. Analysis – separation of a whole into component parts
   - How does _____ compare/contrast with _____?
   - Classify _____ according to _____.
5. Synthesis – combination of ideas to form a new whole
   - What would you predict/infer from _____?
   - How would you create/design a new _____?
6. Evaluation – development of opinions, judgments, or decisions
   - What criteria would you use to assess _____?
   - Prioritize _____.

<u>Note</u>: Adapted from <u>Questioning for Quality Thinking</u> by J. McTighe, 1985, Baltimore: Maryland State Department of Education (also presented in McTighe & Lyman, 1988).

1. A person engaging in dualism holds a world view which is based on polar opposites of black or white, good or bad, right or wrong (Perry, 1970). A dualist in physical education might say that the only "correct" way to do a bench press is with a wide grip.

2. The position of multiplicity is characterized by an acknowledgment that there are multiple ways of viewing the world (Perry, 1970). Put another way, a person at this position has the capacity to distinguish shades of gray. A multiplist in physical education might allow that the bench press could be done with a wide grip or a narrow grip or anything in between.

3. Members of the relativism subordinate group use a procedure to determine which shade of gray has a higher value (Perry, 1970). A person with this perspective might do a muscular analysis and determine that the wide grip is better than the narrow grip in the bench press because it more fully uses the pectoral muscles.

4. Representatives of relativism apply procedures within a context (Perry, 1970). That is, a person at this position will search for the best shade of gray for a given situation. A relativist in physical education might conclude that, for a professional football offensive line player, using a narrow grip in the bench press is better because it approximates the movement used in competition.

The second epistemological scheme (Belenky, Clinchy, Goldberger, & Tarule, 1986) also has four primary perspectives. In general, each of these perspectives is compatible with the similarly numbered position of Perry (1970).

1. People demonstrating received knowledge are characterized by an orientation to authority outside themselves (Belenky et al., 1986). Receiving, retaining, and returning the words of authorities are equated with learning. The one redeeming grace of this group is that they believe that teachers are always right.

2. The next group of students locates at the perspective of subjective knowledge (Belenky et al., 1986). Here, the source of authority is redefined from the external or expert to the internal or inner voice. That is, the words and directives of external authorities become impotent in comparison to the truth of intuitive and sensory experience. Thus, the criterion for truth is "what feels right to me." If you have students who seem to lack input channels, they may be subjective knowers.

3. Members of the procedural knowledge group are absorbed with learning and applying procedures for obtaining and communicating knowledge (Belenky et al., 1986). Professors represent authority because

they possess and transmit the desired procedures or techniques. Procedural knowers are taught to isolate events and people from contexts in order to arrive at objective evaluations. Form takes precedence over content. Belenky et al. never once used the term “yuppie” here. I would have.

4. Representatives of constructed knowledge are striving to integrate knowledge that they feel is intuitively important with knowledge and procedures acquired in formal education (Belenky et al., 1986). They realize that all knowledge is constructed. Theories are not seen as truth but as educated guesswork. Constructed knowers understand that knowledge is dependent on the context of the knower and on the context in which these events occur. In my view, it is difficult to get a one-word answer from someone at this position.

From these thumbnail sketches you may have noticed that many of your students seem most comfortable with the lower epistemologies. If that is the case, you are probably justified in doing some of your communication at these lower levels. After all, learners tend not to do very well when the lesson is over their (epistemological) heads. And this may account for the difficulties many students have with analysis, the first of the procedural levels of knowledge. Of course, if there are problems with analysis for most students, synthesis and evaluation, the higher forms of procedural knowledge, may seem out of the question.

An obvious solution is to help our students make the transition to using the more evolved epistemologies. But this is not easy. Often it is a major breakthrough to get certain students to move from the first to the second level of epistemology as they acknowledge that there are more than two ways (i.e., right/wrong) to perform most movements, or they accept that their feelings and opinions have worth. Other students, who are comfortable with the second level of epistemology, resist the third level of abstract procedures unless they have incentive for the inevitable struggle. For students with a detached, procedural perspective, we need to find ways to help them deal with the nuances and complexities of context. For that is what it will take to succeed with our guidelines.

Other possible reasons that we slight the higher order thinking processes in our classes have to do with our effort and our own epistemology. When we have our students memorize daVinci's muscles or Newton's laws, we are making them received knowers. While that does not take much effort on the part of either the students or the teacher, it can give the illusion of “success.” If we are looking for exams that are easy to grade, true/false questions fit the bill even if that targets the dualistic perspective. Similarly, quantitative problems that have “right” answers are easy to check –

especially so if right answers are rare. Thus, it appears that the low effort formula is to use the first level of epistemology when we want to be simple or “successful” and the third level when we want to be rigorous or righteous.

In contrast to the low effort approach, it is quite challenging to engage students at the second and fourth levels of epistemology. Drawing out student interests about movement, an example of second level epistemology, can yield very diverse, even messy, points of view. Neither is it easy for teachers to operate at the contextual, or fourth, level of epistemology. If each situation is different, how can one assert claims of certainty?

Perhaps with today's audience, effort is not the issue given that you have taken the initiative to attend this conference. But more awareness of our own epistemologies may be in order. For example, how often do we or our colleagues say that a performer's movement is either right or wrong (or correct or faulty/erroneous)? Who is served if we are exemplars of dualism? Most of us have had a highly subjective, even passionate, relationship to moving. Is it wise to eliminate or ignore this? As for operating procedurally, it is easier to deal with the idealized world than the actual one (e.g., where air resistance matters). And how often do we extrapolate the actions of the elite performer as appropriate for us all? Surely we know that acontextual (i.e., one-size-fits-all) analyses have very limited value. Why do we not investigate the influence of context on performance? Why are we averse to constructing an applicable body of knowledge? In my opinion, our field has only evolved to the beginning stages of the third level of epistemology. That is, we use low-level procedures--primarily analysis rather than synthesis and evaluation--and we use them more generally than specifically or contextually. After all, “how do humans move?” is essentially an analysis-type question. No wonder our body of knowledge has trouble with movement.

CONSUMPTION OF KNOWLEDGE

The next question is how do our learners consume our body of knowledge? Sometimes it seems that they have Teflon brain – where nothing sticks (Wagner & Tomlin, 1977). (See Figure 3b.) One reason that our information may not stick is that there is already something there. In other words, our students may not be empty vessels, and preexisting knowledge may take precedence over new information. This relationship between preconception and instruction has been recognized as particularly vexing in the learning of school physics. Given the prominence of physics in our borrowed body of knowledge and in our guidelines, I think it behooves us to consider the nature and scope of this problem and some efforts to understand and address it.

Naive or intuitive physics was first popularized in the early 1980s by McCloskey (1983). He surmised that people who were constantly observing and interacting with objects in motion would have accurate ideas about motion. Instead, he and other scholars (Cooke & Breedin, 1994; diSessa, 1993; McCloskey, Caramazza, & Green, 1980) have found that a high proportion of students from elite universities (e.g., MIT, Rice, Johns Hopkins) who have completed one or more college physics courses seem to hold inaccurate beliefs about motion. In some cases these students make erroneous predictions for simple physical scenarios; in other cases they can solve problems mathematically but cannot explain what happened. How can virtually all people be so good at informal physics (i.e., motor behavior and interacting with objects) and many of the brightest people be so poor at formal physics? Several cognitive and computer scientists have offered opinions as to the genesis and solution of this problem.

McCloskey and colleagues (McCloskey, et al., 1980) argued that people acquire a primitive, non-Newtonian view of the world from their experiences in the world. Calling this point of view naive physics, they claimed that it is a common, robust, and coherent theory of motion reminiscent of the pre-Newtonian impetus beliefs. Further, adherence to this theory was said to be the source of misconceptions and systematic errors which are difficult to dislodge with training in formal physics. McCloskey's solution was to identify and challenge these misconceptions so students could replace them with Newtonian mechanics.

Cooke and Breedin (1994) tested McCloskey's (1983) assertion of the generality of naive impetus theory. Instead of having a coherent theory, they concluded that students construct explanations of motion "on the fly" by using a combination of contextual cues and relevant knowledge. In fact, they contended that humans are especially sensitive to contextual factors and that novices are more dependent on context than experts. Thus, Cooke and Breedin recommended that instruction target the distinction between relevant and irrelevant contextual cues.

The influence of context in naive physics was also probed by Ranney and Thagard (1988). They pointed out how something could be believed in one context but not in another. Given their belief that people seek explanatory coherence, they suggested the following instructional strategy: ask students to make extended explanations of physical scenarios and encourage them to revise their beliefs to become more coherent.

From a more theoretical perspective, diSessa (1993) endeavored to understand the intuitive sense of mechanism that accounts for common sense predictions and explanations. In his view, a person begins to develop this sense through numerous unarticulated interpretations of experienced reality (e.g., basketballs bounce). Over time these interpretations get clustered into minimal, primitive abstractions of common phenomena – sort of a small, intuitive equivalent of a physical law (e.g., lots of different balls bounce). Once built, these "primitives" provide a schemata for observing and interpreting the world. Because they are cued by perception, people learn to activate them in (mostly) appropriate circumstances. For novices these primitives are not very focused, logically organized, or tightly connected. Rather they are local and ad hoc – which accounts for why different explanations can be given for similar phenomena (cf. Ranney & Thagard, 1988). diSessa described the process of becoming expert as one of reorganizing and prioritizing one's existing phenomenology. In other words, primitive notions get tuned to have higher or lower priority and the contexts in which they are activated can migrate, expand, or contract; novices begin to notice and respond to the same features that experts do (cf. Cooke & Breedin, 1994). Evolution is toward compactness – to have a few principles as general as possible. (E.g., Balls bounce, but, at a more fundamental level, energy and momentum are always conserved.) However, this reduction to general principles proceeds only when it is required, and, then, by stages. According to diSessa, if intuitive and expert reasoning are continuous, a person should not have to give up everyday reasoning and, indeed, might become alienated if an unwarranted wall were built between prior knowledge and scientific understanding.

In their review, De Kleer and Brown (1984) outlined some of the general features of the emerging knowledge domain that has been variously called naive physics, qualitative physics, commonsense knowledge, or mechanistic mental models. For the framers of this domain, the central intent is to formalize commonsense knowledge. In so doing they hope to delineate a form of physics that 1) provides causal accounts of physical mechanisms that are easier to understand than classical physics, and 2) retains all the important distinctions of physics without invoking the mathematics of continuously varying quantities. According to De Kleer and Brown, such a physics would be built on qualitative concepts and distinctions; and the most important property of a quantity would be whether it was increasing, decreasing, or unchanging. Then more information, such as interval arithmetic for variables, could be added as helpful, but not required. Although exact values could be used to describe a system, De Kleer and Brown opposed this when the intent is to gain insight into how a system functions.

Forbus and Gentner (Forbus, 1984; Forbus & Gentner, 1986) added detail to some of the issues of De Kleer and Brown (1984). First, they emphasized the importance of uncovering the ideas of physical reality that people actually use in daily life. They presumed that people use conceptual, qualitative representations of the physical world because such representations can be derived from observation, expressed in simple language (e.g., numbers are not needed), and used as the basis for interpretation and conjecture. Second, Forbus and Gentner theorized about the transition from commonsense knowledge to expert knowledge. They postulated an expert knowledge grounded in conceptual representations that organize and orchestrate the use of more detailed knowledge. For example, if a basic dynamic theory is defined using qualitative representations, then more precise information (e.g., interval arithmetic) can be added to provide more precise conclusions. But, as Forbus and Gentner contended, the same conclusion should be drawn with more precise data as with weak data. Ultimately an expert physicist would build on this quantified, conceptual understanding to construct the simplest models that can make detailed predictions about phenomena. Thus expert knowledge can be expressed in equations, but experts also continue to use qualitative reasoning as rules of thumb (e.g., knowing when something can be ignored) and in many contexts (e.g., if there is significant uncertainty in a situation, qualitative representations provide appropriate resolutions because they are not computationally intensive and do not generate misleadingly detailed predictions). In this view, people keep most of their stored knowledge as they move up in levels, and true experts know which level of knowledge to use in which situation.

In sum, our students are not likely to be empty vessels. Rather they are apt to have an above average amount of experience from engaging with the physical world. If the path to expertise is anchored in experience, then perhaps we should consider some of these strategies for drawing out and developing our students' embodied knowledge. And we might think about how much expertise in physics our students really need to operate in our contexts which include significant uncertainty.

Another reason that our information does not seem to stick in our students' brains is that we may be supplying inappropriate information. For instance, dualistic information in a complex, contextual world is not likely to do much good. And information that is contrary to our perceptual abilities is unlikely to help. According to Johansson (1975), humans perceive movement differently than cameras do: Cameras are great for recording slices or snapshots of movement, but they are not so good for recording continuous sweeps of movement. Humans, on the other hand, are much better suited to take in sweeps rather than snapshots of movement.

Some of the disappointing results from the movement observation literature can be explained by these epistemological and perceptual factors. For example, Hoffman and Armstrong (1975) used two forms of dualism as well as snapshot-like events in their observation study of the standing long jump. They identified jumps as "correct" or "incorrect" and asked observers to supply "yes" or "no" answers to queries about "errors" such as "were the upper arms swung rearward so that they were at least parallel to the floor?" (p. 211) Even though trials were presented both in real time and at three times slower than real time, the typical observer had less than 70% accuracy on incorrect performances. And subjects with "carefully programmed visual and verbal training" were not functionally better than the control group in "discriminating errors" (p. 212).

Moving to the other extreme in observation studies, no one has reported evidence that observers can accurately quantify specific angles and the like in dynamic, real-time situations. If neither crude (i.e., dualistic) nor precise formulations for observation seem likely to stick in our students' brains, perhaps we should consider other approaches. For example, Forbus and coworkers (1997) have found that both novices and experts, who are solving problems in physical domains, rely on common sense reasoning and qualitative representations. When numerical values are needed, they are quite commonly expressed as ordinal relationships.

In his book about the meanings we make out of embodied experiences, Johnson (1987) explains how the scale schema is basic to both the qualitative and quantitative aspects of our experience. With the scale metaphor we are able to merge a sense of quality with discrete quantities. Indeed, musicians seem to understand how qualitative concepts such as volume and tempo can be represented by ordinal measurement (see Figure 4). We biomechanists, on the other hand, only seem interested in analyzing performance with the greatest possible quantitative precision.

CRITIQUE OF KNOWLEDGE

Now it is time for the summary critique of our body of knowledge: We may be in a near-terminal state – in other words, our "body" may become the chalk line on the sidewalk if we do not get beyond the analytic question of "how do people move"? and the answers that tend to be dualistic or excessively quantified. In fact, if we do not get busy developing an applicable body of knowledge, the pertinent question may be, "Was it homicide, or was it suicide"?

Fortunately, I think there are some things that we can do to resuscitate our body. The first is a subtle shift in our central question. Instead of asking “how do humans move”?, we might ask “how do humans move better”? By better, I mean more skillfully and more safely. This slight shift in emphasis should allow us to get beyond the level of analysis and into synthesis and evaluation. Perhaps then we can generate the information that will get us into the Yellow Pages.

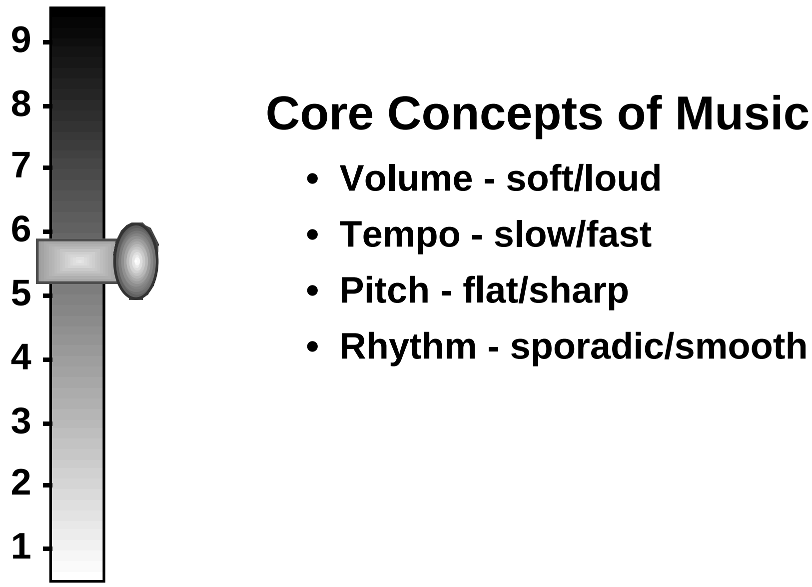

Figure 4. Sliding scale (i.e., simple quantification) of qualitative concepts in music.

In addition, there are some relatively simple things we can do in our classes. For example, we can use Ruth Glassow's teaching strategy of presenting a relevant problem then providing the information that the students use to solve it (Luttgens, 1978). Lela June Stoner (1984) has had good success by showing movie clips of diverse movers and asking her students to tell which performer was more skilled and why.

Another strategy is to find out what our students already know about “how humans move better.” I have tried this, and I have found out that my students are “everyday geniuses” (Kline, 1988, p. 6). After all, they have been observing movement and drawing conclusions from an early age. My students seem to possess what I call common knowledge biomechanics. In particular, they seem to arrive at my class with a good background in the core concepts of kinesiology (Hudson, 1995) (see Table 3).

Table 3
Core Concepts of Kinesiology

1. Range of motion
2. Speed of motion
3. Number of segments
4. Nature of segments
5. Balance
6. Coordination
7. Compactness
8. Extension at release
9. Path of projection
10. Spin

In general, I believe that these core concepts form a visual vocabulary that can be used to help humans move better. A selfish benefit of these core concepts is that they have helped me get better teaching evaluations. Here is the trick: On the first day of class, tell your students they are geniuses. Some may be skeptical, but most are willing to suspend disbelief for a while. On the second day of class, draw the core concepts out of your students by having them identify characteristics that distinguish a skilled thrower or tennis server from a less skilled performer. Collectively they should be able to generate most of the ten concepts. Continue to use the core concepts where appropriate throughout the semester and reinforce episodes of genius behavior. And you might find, as I have, that both learning and course evaluations improve. By the way, you are more experienced with movement than my students, so you are quite probably geniuses, too.

To summarize, I suggest that we educe common knowledge biomechanics from our students. This allows us to congratulate them for what they already know, and we can save some time by not covering things that do not need to be covered. It also lets us find out what oversimplifications and misconceptions are held so we can help students deepen their understandings and, if necessary, revise their beliefs. In addition, I maintain that we should try to identify uncommon knowledge biomechanics. That is, I suspect that the eventual body of knowledge that we build will include some elements that will appear to be counterintuitive.

CONSTRUCTION OF KNOWLEDGE

As we generate the elements that will become our unique body of knowledge, it might help to begin with a skeletal model such as the one in

Figure 5. These boxes are arranged from the most disciplinary on the left to the most applied on the right. We begin with our borrowed disciplinary content from gross anatomy and classical mechanics. Then we add boxes for the basics of skillful and safe movement, observation and alteration of movement, and interpretation of movement to learners. You may already have some ideas about what might go into these various boxes. And that is a good thing, because you know that it will take many people to construct the knowledge that will enable us to help humans move better.

To help you imagine what sorts of knowledge we might construct, I would like to talk about a few of the studies that my students and I have conducted. For many years I have been interested in the second-to-the-left zone of the model in Figure 5. In particular, I have sought to identify some of the distinguishing features of skilled movement. This research might be framed by the question "How do differently skilled humans move"? First, I studied the basketball free throw (Hudson, 1982, 1985a, 1985b). My subjects were college women from international, intercollegiate, and instructional skill groups. Skill was identified by status as well as by multivariate discriminant analysis and comparison of made vs. missed shots. In brief, I looked at the core concept of extension at release – the skilled shooters had a significantly higher point of ball release compared to the less skilled shooters. Also, I looked at balance – the better shooters had relatively high stability and relatively low mobility – that is the line of gravity was centrally located over the base of support, and they had little horizontal mobility at the time of release.

Next I studied the vertical jump taken without an arm swing (Hudson, 1986; Hudson & Owen, 1981, 1982). The subjects were female and male jumpers and runners. When skill was defined traditionally (i.e., by jump height), nothing was significant. An intra-individual conception of skill (i.e., improvement of countermovement jump relative to static jump), however, was quite discriminating (Hudson, 1991). The concepts I investigated were range of motion, speed of motion, and coordination. The most skilled subjects did not crouch very deeply in their jumps, they completed the thrust of the jump quicker than the less skilled subjects, and they had a near-simultaneous pattern of coordination. Although the less skilled subjects had a less simultaneous pattern of coordination compared to the better skilled subjects, their pattern was still predominately simultaneous.

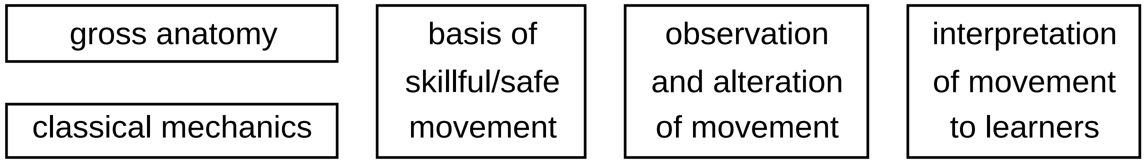

Figure 5. A skeletal body of knowledge for biomechanics.

Scott Strohmeyer expanded the jumping analysis by investigating coordination in the vertical jump with an arm swing (Strohmeyer & Hudson, 1991). His subjects were female intercollegiate athletes; his identification of skill was intra-individual (i.e., improvement of arm-swing jump relative to no-arm-swing jump). He found that the best jumpers were able to synchronize their arm swings with the flexion and extension of their legs such that the arms reached verticality (or the bottommost point in their arc) simultaneously with the thighs reversing from flexion to extension. In other words, the arms and legs were synchronized to be moving downward at the same time, then upward at the same time.

Mike Spina extended both the shooting and jumping research by looking at balance in the jump shot (Spina, Cleary, & Hudson, 1996). He did a comparative case study of an advanced performer and an intermediate performer. The intermediate performer exemplified a larger base of support by using a staggered stance, but the smaller base of the advanced performer may have allowed a better jump. Both performers maintained their lines of gravity within their bases of support, but the horizontal movement of the advanced performer was in better control, and his shots were more accurate. So, in this case, less stability and less mobility were associated with better skill.

In sum, the aforementioned studies would fit into the basics of skillful movement domain of Figure 5. In this research we looked at five core concepts – range of motion, speed of motion, balance, coordination, and extension at release. These studies, however, were descriptive and comparative, so experimental investigations are needed as follow-up.

Michael Bird looked at the issue of observation (Bird & Hudson, 1990). He wanted to find out what observers would report about movement in an open-ended format. His subjects were novice observers (i.e., liberal arts majors with no formal experience) and experienced observers (i.e., motor skill teachers). After repeated viewings of a videotape of a novice lacrosse thrower, they listed characteristics of the mover that would be relevant for instruction. The experienced observers identified more characteristics and needed fewer iterations to do so. For both groups of observers the noted characteristics were quite compatible with the core concepts and tended to occur more often in the slower, preparatory phase of the movement. From these results, it appears that both novice and experienced observers come equipped with a common knowledge biomechanics.

Moving on to the alteration of movement, Mark Eddings conducted an experimental study of the free throw (Eddings, 1996). His volunteer subjects were recreational and intercollegiate basketball players. Each subject was individually videotaped on two separate days in a pre-test and a post-test of 20 free throws. Prior to the post-test the members of the experimental group were asked to arch their shots more and were given five minutes to practice. Not only did the experimental subjects significantly increase their angle of projection, they also demonstrated a higher point of release. Thus, they derived both direct and indirect benefit from this alteration. Also, some of the less accurate shooters made substantial improvements in accuracy with this simple cue.

Andrea Ross investigated an indirect way to improve skill by changing the environment (Ross & Hudson, in press). She thought that jumping on a mini-trampoline might improve the height and technique of jumping. The reasoning was twofold: First, a jumper needs many, many repetitions to develop skill; the cushioned bed of the mini-tramp might allow multiple jumps with less repercussion from landings. And second, the adjustments that are made to jump on a mini-tramp might educe beneficial changes in technique. The subjects were intercollegiate basketball players who performed 60 mini-tramp jumps a day, twice a week for 5 weeks during the post-season. Maximum vertical jumps were tested on a Vertec in the gym and videotaped in the lab before and after the intervention. As a group the subjects jumped significantly higher and with better balance after using the mini-tramp. Range of motion and coordination also changed in individually beneficent ways for most subjects. Thus, specific, anticipated changes in technique were achieved without mentioning any biomechanical cues to the subjects.

To recapitulate, Figure 5 is a skeletal model for a body of knowledge in biomechanics. My genius students have been fleshing out this body. We began with the second-to-the-left zone and tried to identify some of the basic characteristics of skillful movement. In my estimation, this is the “guts” of our body of knowledge. Then we moved into the third-to-the-left zone to find out what people see when they observe movement. This would be analogous to the “eyes” in the body of knowledge. Also, in this area of the model, we did some experimental work where we tried to alter the skill of particular subjects. This required quite a bit of synthesis and evaluation, so this may be the “gray matter.” Finally, in the right-most zone, we did an experiment where we changed technique by changing the environment. Since this is the place in the model where suggestions are verbalized, this area is rather like the “mouth.”

There is quite a bit about the body of knowledge that we do not know yet. In particular, we have not investigated the basics of safe movement. Presumably the basics of safe movement will be similar to the basics of skillful movement, but we cannot really say that now. Although there is much knowledge yet to construct, I believe there will be a big pay-off for doing so. First, there should continue to be jobs for ourselves and our students. Indeed, we may even have listings in the Yellow Pages. And finally, we, as well as everyone we know, will be enabled to move more skillfully and more safely.

Since you and your students are geniuses, I invite you to help us construct this new and useful body of knowledge in biomechanics. As it begins to take shape, it may look something like Figure 6.

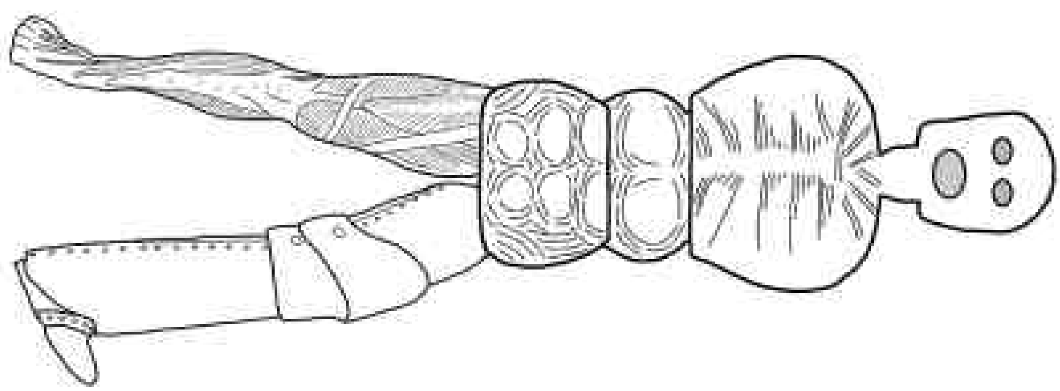

Figure 6. An early stage in the evolution of the biomechanics body of knowledge.

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