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A "Peer Interview About Complex Events" Method as Used in an Investigation of Students' Preinstructional Knowledge of Mechanics

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An important aim of conceptions research is to determine the nature and content of students' knowledge prior to instruction. Methods used to investigate students' preinstructional knowledge of mechanics include a number of variations in which subjects are asked to respond to physics questions or tasks. Some involve giving students paper and pencil tasks such as open-ended qualitative dynamics problems (Clement, 1982; Viennot, 1979) or multiple choice problems (Halloun & Hestenes, 1985; Whitaker, 1983). Others involve interviews of students such as the interview-about-instances (Osborne & Gilbert, 1980) and the interview-about-events (Gilbert, Osborne, & Fensham, 1982) methods where the interviews are organized around physics concepts such s have generated student answers and explanations some of which, when judged by the standards of classical mechanics, are incorrect. Analysis of the mistakes has led to varied claims regarding students' conceptions. These studies and the claims generated thereby have enjoyed great currency.

Concerns have been raised, however, about a researcher's capacity to make inferences about students' conceptions from their answers to the researchers' questions. Perhaps the earliest *caveat* — it predates all of the studies mentioned above by a half-century — appears in the introduction to Piaget's (1929) The Child's Conception of the World. In a discussion of the relative merits of children's answers to questions put to them by adults, Piaget warns that "it may well be that a child would never put the question to itself in such a form or even that it would never have asked such a question at all" (Piaget, 1929, p. 3).

Piaget goes on to say that answers to such questions may be valuable, but that they do not have the same value as answers to questions that occur naturally to children. Even assuming that a question is not suggestive of a particular answer or type of answer, if it is a question that is unlike those that children naturally ask or think about, at best it can lead to a liberated conviction. Liberated convictions are original products of children's thinking and are resistant to counter-suggestion, but are necessarily influenced by the questioning "since the particular way in which the question is worded and presented to the child forces it to reason along a certain line and to systematize its knowledge in a particular manner" (p. 11).

In contrast, spontaneous convictions are original products of children's thinking which are not influenced by the examination and which, therefore, are all the more valuable to the researcher. That Piaget believes this distinction is important is clear: "It is alarming to think of the exaggerations that would result from questioning children on a number of subjects and regarding the answers thus obtained as being all of equal value, and as revealing equally the child's mentality" (p. 25).

Piaget's distinction between liberated and spontaneous convictions has not been an issue of concern in recent physics conceptions research, nor is it an issue in this paper. His argument that student answers that are influenced by the form and content of researchers' questions are less valuable than student answers to their own questions has, however, resurfaced in criticisms of studies of students' knowledge. The theoretical difficulty posed by using student answers to researchers' questions to determine what students know is an issue of concern in this paper.

Some of the recent criticism focuses on the potential for a researcher's questioning to dictate the surface organization of students' responses, thus providing little or no information about the internal organization of their cognition. Phillips makes the point succinctly: "An answer, if it is to count as an answer at all, *must by conceptual necessity* reflect the structure of the language or discipline presupposed by the question — there is no other alternative" (Phillips, 1987, pp. 137-8). It is evident that Phillips is describing the same phenomenon as Piaget's liberated conviction (although he disagrees emphatically with Piaget about the value of this kind of data). Willson echoes this point: "The content and organization of a question, *with perhaps the important exception of free response not initiated by experimenter*, imposes an organization on the subject's response that does not necessarily mirror the internal representation of the response" (Willson, 1990, p. 72, italics added).

McClelland, in his criticism of the interpretations of interview data, suggests as Piaget did that students may have never thought about the phenomena that researchers ask them to explain:

> If a research worker effectively says to a child, "*I want you to tell me what you think about X*", and *X* is part of usual experience, it would be very difficult for the child to reply, "*I do not think about X*". Some sort of answer is imperative.
> (McClelland, 1984, p. 4)

As an illustration of the significance of this point, consider the following excerpt in which a student, Jane, responds to the question of what makes ball bearings stop as they roll along a floor:

> I don't know. Why do they stop? It's just they always stop. After you push it they go as far as the push . . . how hard it was and after that wears off it just goes back like it used to be. (Driver, 1983, p. 26)

Ball bearings coming to a stop as they roll across a floor are a part of usual experience, but there is evidence in this quote that Jane had not previously thought about why. Her answer that the push wears off is an original product of her thinking, but she is considering a problem which may not have been an original product of her thinking. To claim that Jane had a preconception about why balls stop rolling would be clearly unwarranted because the question did not originate with her. But even to claim that Jane had a preconception in which pushes are things that can "wear off" is problematic. It may be that she invented this explanation by relating two ideas ("pushes" and "things that wear off") which, for her, were previously unrelated.

Piaget's recommendation to avoid this problem is that research dealing with the thinking of children must begin and end with observation: "It is the observation of the spontaneous questions of children which furnishes data of the highest importance. . . . When a particular group of explanations by children is to be investigated, the questions we ask them will be determined in matter and in form, by the spontaneous questions actually asked by children" (Piaget, 1929, pp. 4-5).

My purpose in this paper is to describe a research method which aims to generate data about the motion preconceptions of high school students. The method was invented with certain ideas from the philosophy of science in mind and it was this that led to a focus on the matter and form of the questions actually asked by students. It is my intention to show that this new method avoids the theoretical difficulty described above by allowing the students to determine their own questions.

THE PEER INTERVIEW ABOUT COMPLEX EVENTS

Research methods are only one part of the production of knowledge claims. They are inextricably connected to the other elements of the investigation — the conceptual elements (world view, theories, concepts, assumptions, etc.), the research questions, and the intended nature of the knowledge claims, for example (cf. Gowin's Vee, Novak & Gowin, 1984). Therefore, I will begin with a brief description of the aims and theoretical framework of the study for which the peer interview about complex events method was invented.

While the complete study is complex and includes several methods that each address multiple research questions, I will focus on only those aspects which are most closely connected with the peer interview about complex events method. An assumption of the study was that certain principles from the philosophy of science pertain as well to students' knowledge of the world. Namely, in the same way that a scientific paradigm (Kuhn, 1970) or a conceptual ecology (Toulmin, 1972) determines how a scientist sees the world, a student's knowledge determines the way in which she sees the world. Hills captures the essence of this assumption in his proposal that there is a commonsense framework that students use to "carve up experience in ways which differ from [the] scientific framework" (Hills, 1989, p. 170). Therefore, in an effort to characterize students' preinstructional knowledge in mechanics, specific research questions of the study addressed the students' views of the world. Two research questions that the peer interview about complex events was designed to address are:

1) What events, questions, and problems do students who are untutored in physics address when attempting to explain motion?

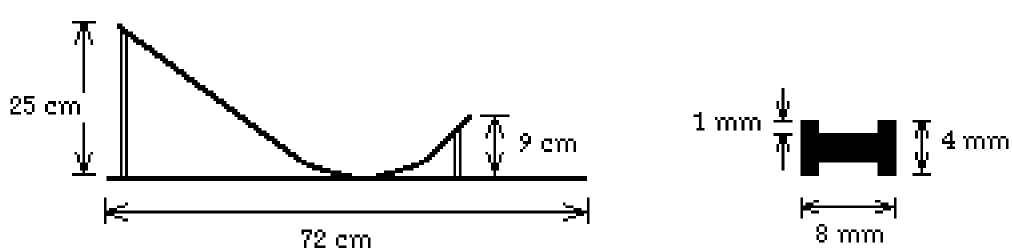
2) When discussing motion phenomena, what characteristics of events and objects do students consider relevant?

In order to answer these questions, a method of investigation was needed that allowed students to determine for themselves the problems, questions, and events to be addressed, the appropriate manner of explanation, and the characteristics and phenomena to be considered relevant. The research method should approach the ideal of a spontaneous conversation between students — two students discussing freely the motion events of their choosing and trying to solve the problems that they see as meaningful and important. The data of interest are not only the explanations that the students give, but the phenomena that they attempt to explain and the questions that they address.

Still, the students' conversation must be constrained to the domain of events of interest in the study. Therefore, a set of three complex events, each one rich in potential for discussion, were designed to stimulate student conversation. As used here, the term "complex event" refers to a short demonstration or experiment that may be seen as being composed of several simpler events. Just what those simpler events are depends on the knowledge of the observer.

The complex events were designed to be complex enough to provide legitimate freedom for the students to carve them up in ways that are consistent with their knowledge and simple enough so that a student could consider the whole complex event without overloading her working memory. They were also designed to allow that students could see and discuss certain phenomena of interest to the research (i.e., projectile motion) without predetermining that they will do so. Finally, common materials and simple apparatuses were used to stage relatively ordinary events — events that are similar to events the students are likely to have encountered.

One of the three complex events was the marble jump. It took place on a ski-jump shaped track. The track was a plastic I-beam (used in model making) bent into a curve and mounted on a platform (see Figure 1). A marble released at the top of the track would roll down, up, and fly off the lower end of the track landing on the platform, about fifteen centimeters from the end of the track.



(a) Side view (b) Cross section of track

Figure 1 — The Marble Jump Complex Event

The other two complex events were a penny propelled into the air by a lever and the bounce of a rubber ball.

In order to approximate the ideal of a free conversation but still provide a procedural structure for discussion of the complex events, a peer interview format was chosen. In the peer interview two students trade roles as interviewer and respondent. The student-interviewer asks the questions and poses the problems. The respondent, of course, responds. When the student-interviewer runs out of questions, the students switch roles. This format provides a procedural structure in that it organizes the social interaction between the students, but not the content of their conversation. In the peer interview, the students determine for themselves the questions, problems, and events to be addressed.

Because of the procedural structure of the peer interview, the students explore the events and questions that they construct more extensively and with more reflection than they would likely do in a truly spontaneous conversation. For this reason some of the ideas they express are probably invented on the spot. Even so, the data generated are not subject to the same criticisms as students' answers to researchers' questions; in the peer interview, the students are addressing their own questions and determining their own line of reasoning.

THE NATURE OF THE DATA GENERATED

As an illustration of the students' freedom to determine their own events and questions of interest, consider the following passage in which MAR and VIC (two high school freshmen) first encounter the marble jump (res = researcher, two dots indicate a short pause, / = upward inflection):

res once again considering what kinds of things we're doing here what do you think we might do with this/

MAR place it [the marble] from one end and see what happens . . how if you place it up here [at the top] and see how, what happens if you place it here [the lower end] . . how high it goes

res so VIC why don't you be the first interviewer and ask her some questions before you actually try it

VIC what do you think will be the overall effect if you just start from this end [the top]/

MAR actually my first thought was that it would fly off . . but then when it came down here [the curve at the bottom] it just kind of looks like it would lose a lot of its speed and just maybe hit here [the end of the track] and roll back down . . it wouldn't really go off . . cause of the shape . . there's such a large dip

VIC do you think it will do the same on the other side/ [if the marble is started at the lower end]

MAR I don't think it'll go that high cause again it loses speed . .

The main questions for VIC and MAR in their first encounter with the marble jump were: 1, will the marble fly off when started at the top of the track, and 2, how high will it go if started at the lower end of the track. That the peer interview about complex events provides information about the students' questions is important because their explanations must be analyzed in regard to the questions that are being answered. The claim that MAR knows that how high a marble will roll up a slope depends on its speed is justified by the fact that she introduced the question of how high it would roll and used the concept of speed to explain her prediction. On the other hand, that she thinks that the marble will lose speed while traveling over the curved section of track must be considered in the context of her prediction that the marble may not fly off. She was not directly concerned with explaining changes in speed; therefore, her statement that "the marble would lose a lot of its speed" was more a justification of her prediction than a statement of conviction regarding motion through a curve. Later in the peer interview, when they are addressing a different question, VIC and MAR propose that marbles may actually gain speed in the curved section. It seems more prudent to claim that MAR believes the shape of the track to affect the speed of the marble and that, in the case of a curved section, the effect of the shape is not well understood.

This next example also shows the importance of considering the question being answered when analyzing an explanation. ANN and DIA are addressing the question of whether the marble will go off. DIA has finished asking questions and ANN is just taking the role of interviewer.

ANN okay what did you think was going to happen when the ball, when we put the ball there [at the top of the ramp]/ did you think it was going to go over/

DIA yeah I thought it was just going to go over . .

ANN oh

DIA but . . because it started here [A in figure 2] I think it just gained some force right there [X] and speed and stuff like that and it just went over . .

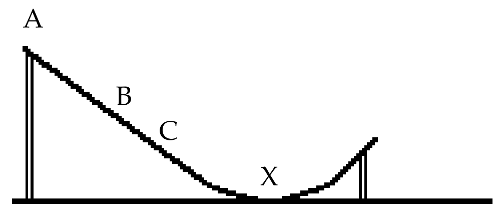


Figure 2 — DIA's explanation

but if you like start from here [releases marble at B, marble goes over] . . it didn't go as far . . and if you start here [releases marble at C, it does not go over] it didn't even go off . . that's what I thought . . I thought because you started here [A] it was going to go, it was going to travel faster from here [about midpoint on slope] and it was going to gain strength and speed

ANN uhhuh

DIA and it went over . . that's what I thought

DIA says that, if the marble starts at A, it will gain force (or strength) and speed and that is why it “went over”. Up to this point in their interview, the question “will the marble go over?” has been raised by both ANN and DIA. So DIA’s introduction of the concepts of force, strength and speed are related to that question. To conclude that DIA knows that it takes strength/force/speed for a marble to “go over” requires evidence that the question of going over is not foreign to her knowledge of motion. There is such evidence.

ADVANTAGES OF THE PEER INTERVIEW ABOUT COMPLEX EVENTS

The two passages above illustrate that the peer interview about complex events generates data about student knowledge that include questions as well as explanations. This focus on student questions has two main advantages. First, by allowing students to answer their own questions, it warrants stronger claims about what students know. Second, by generating student explanations within the context of their own questions, it provides a new avenue for hypothesizing about students’ preinstructional knowledge.

In their article, “Qualitative research: From methods to conclusions”, Lythcott and Duschl (1990) argue for improvements in the quality of research design and practice for studies involving verbal data. They promote the use of a model of argumentation, developed by Toulmin, where the steps from data to claims are based on general hypothetical bridges, or *warrants*. Warrants, in turn, are supported by *backings*, or assurances, without which the warrants would be illegitimate (Toulmin, 1958). To illustrate the use of warrants in science education research, Lythcott and Duschl refer to the same excerpt involving Jane and the ball-bearing rolling to a stop that I quoted earlier and repeat here as a reminder:

> I don't know. Why do they stop? It's just they always stop. After you push it they go as far as the push . . . how hard it was and after that wears off it just goes back like it used to be. (Driver, 1983, p. 26)

The warrant, or general hypothetical bridge, that they propose for moving from this explanation of Jane's to the claim that Jane knows that rolling balls stop when the push wears off is this: "Novel verbiage used by an interviewee, (verbiage that has not been introduced into the conversation by the interviewer), reflects a part of the cognitive system of that student" (Lythcott & Duschl, 1990, p. 451). In applying this warrant to Jane's speech, they state that:

> The language of push, wears off, and the implication that when there is no more push, the rolling ball stops, are all claimed to be something that the student knew, that is was in his/her cognitive system somehow. This conclusion is defensible because the warrant is defensible; where else could novel verbiage, the words and their relational meanings have come from if not the cognitive system of the speaker?
> (p. 451)

This warrant is backed by an assumption that both the words and their relational meanings existed, in some way, in the student's cognitive system prior to the interview. The assumption is consistent with the theoretical framework that drives much research into students' conceptions, but is it a strong enough backing to assure the authority of the warrant? Certainly students are not likely to coin new words during an interview. However, it seems quite likely that a student might construct a new relationship between concepts during an interview. Let us suppose that Jane's idea that 'when there is no more push, the rolling ball stops' was constructed during the interview. Would it then be something that she knew, that was in her cognitive system somehow? Perhaps if the construction was, *in every way*, Jane's own construction, then we could say that it was something that she knew. But in this case, I submit that the structure of the construction was suggested, if not required, by the researcher's question. In order to answer the researcher's question, Jane was compelled to make a statement of the general form: 'if (or when, etc.) ______________ happens, then the ball stops.' Otherwise, she would not have answered the researcher's question of why the ball stops.

Perhaps Jane knew that 'pushes can wear out', but she had never related that conception to the question of why a ball bearing comes to a stop because she had never asked that question of herself. Or perhaps Jane never before considered a push to be something that wears out — she may have reasoned that, "I must explain why the motion dies out . . . I know that pushes are responsible for motion . . . since the motion dies out, then maybe the push also dies out or wears off". To say that Jane knew that when there is no more push, the ball stops rolling is to claim that Jane had an explanation for the ceasing of motion of a rolling ball. This is the claim that I believe is unwarranted by interview methods in which the researchers pose the questions and the students answer.

In contrast, the claims that MAR knew that how high the marble rolls depends on the speed of the marble and that DIA knew that the marble needed to gain strength/force/speed in order to go over are authorized by a stronger warrant — a warrant of the form: novel verbiage *used spontaneously by a student, or used to answer a question of her own devising*, reflects a part of the cognitive system of that student. This warrant is stronger because it provides a more defensible answer to the question: where else could the novel verbiage come from but the cognitive system of the student? The answer is that, since nothing in the interview suggests the words <u>or</u> the structure of appropriate response, the novel verbiage of the student must come from her cognitive system alone.

It is important to point out that, in order to use the warrant as I have presented it with data generated by a peer interview, care must be taken to establish which statements are spontaneous or responses to questions which originated with that student, and which are answers to questions posed by the other student. If an answer is prompted by a question asked by the peer, then it may still lead to a defensible claim of what the student knows if there is evidence that the student had already considered that question or one like it. Finally, certain questions were asked in each and every peer interview, such as the first question posed by MAR: Will the marble fly off the ramp? It seems safe to treat any answer to such a question as if it were a spontaneous explanation.

In addition to providing a stronger warrant for claims regarding what students know, the peer interview about complex events provides a look at the nature of students' explanations that is different than the generally reported findings. In most researcher-student interviews, the researcher determines the questions and sets the standards for acceptable explanation by either probing further or letting student propositions stand. In peer interviews, since the students generate the questions and the answers, they are the arbiters of what events require explanation and what constitutes appropriate explanation of those events. The clearest examples of this come from passages in which students are explaining the complex event that I call "the penny flip" (see figure 3).

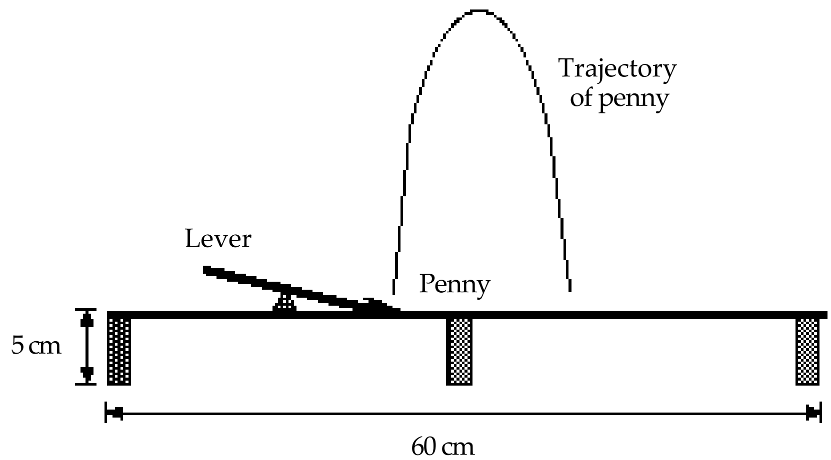


Figure 3 — The Penny Flip Complex Event

When the end of the lever is pressed down rapidly, the penny flies up and to the right (as shown in figure 3). This was, for almost all of the students, a discrepant event. With very few exceptions, the students expected the penny to fly to the left. In the peer interviews a great deal of intellectual effort went into the problem of the direction of flight of the penny. When a student-interviewer asked her peer why she thought the penny would go to the left, the answers often indicated reliance on past experience or analogies (these are excerpted from different peer interviews):

LYN cause I've tried it at home

MAR ever take a sugar bag and put it on a fork and it always flies the way you push down on the fork/

MAN because you know on TV you see a catapult and it goes that way

KAT like on a seesaw too like when two people are on it even if one person gets off the other one will fly up like that

LOU most of time . . like . . when kids do it . . .

This evidence indicates that students, at least sometimes, make predictions based on analogical reasoning — the event is seen as similar to familiar experiences in which the outcome is known. This claim is in contrast to the widely accepted claim that students' rely on intuitive rules such as "motion implies force" (Clement, 1982) or the "straight-down belief" (McCloskey, Washburn, & Felch, 1983) for predicting events. Their predictions about the penny flip suggest that the preinstructional knowledge upon which the students relied consisted of something other than a set of intuitive rules. This hypothesis is supported by the variety evident in the students' attempts to make sense of the actual trajectory of the penny. Their explanations show no uniformity nor any reliance on common rules of motion when explaining why the penny goes to the right:

KAM do you think cause um. . it's not high enough . . the. . the um mechanical thing [lever]/. . the seesaw . . imitation seesaw/

MAR if you put something with more weight on one side [referring to the lever itself having one side heavier than the other], usually a penny doesn't go to the side or anything light doesn't go to the side that has weight on it

VIC it [the penny] kind of looks like it's half on half off so maybe if it was on [the lever] all the way . . the way it's positioned . . I'm just guessing

LYN maybe because it's on that little like round thingy right there [an indentation on the platform] and first . . if you hit it [the lever] that way [down] then that thing [the indentation] will make it [the penny] go that way [to the left]

ROB I thought maybe if you hit it [the lever] hard enough it [the penny] would probably like go up and go a different direction

LAT do you think that the weight has anything . . like the weight of the penny has anything to do with it falling back this way/

DIA if you did it like slower it would probably have gone that way since you hit it fast it probably went up instead of going that way . .

The remarkable uniformity of the students' spontaneous, but incorrect, predictions that the penny would go to the left suggests that they are relying on similar knowledge to make their predictions. If that knowledge is in the form of a set of rules of motion, then they would be expected to approach the problem of the discrepancy along similar lines. The lack of similarity in students' attempts to make sense of the event as it happened suggests that that similar knowledge is not in the form of rules of motion. On the other hand, in seven of the nine peer interviews, an analogous event, usually either a seesaw or a catapult, was proferred as an explanation of why the student expected the penny to go to the left. (As for the remaining two interviews, one did not include any predictions about the direction of the penny's flight and the other did not provide any information about why the students thought it would go to the left.) The evidence above supports the hypothesis that, in this case, the students made their predictions based on experiential knowledge of similar events and then searched for rules to either support their prediction or explain why the penny behaved differently.

This in no way refutes the claims that students rely on "motion implies force" rules or "straight-down beliefs" to solve physics problems. The preponderance of the evidence from multiple studies shows that, *when asked to identify the forces* acting on moving objects (Clement, 1982; Viennot, 1979) or *when asked to predict the trajectories* of carried objects (Fischbein, Stavy, & Ma-Naim, 1989; Galili & Bar, 1992; McCloskey, et al., 1983), student answers are consistent with those intuitive rules of motion. On the other hand, data generated by the peer interview about complex events indicates that, *when students are allowed to determine their own questions* and lines of inquiry, preinstructional knowledge of a different sort is in evidence.

Therefore, while students may use rules such as "motion implies force" to respond to physics questions which ask about forces, the data generated in this study indicate that they do not use such rules when forming their own questions. This finding does refute the claim that the "motion implies force" rule is a *preconception* in which "continuing motion implies the presence of a continuing force in the same direction as the motion" (Clement, 1982, p. 67). If it is really a preconception — a "*plausible theory* that has been constructed by students" (p. 69) — then there should be some evidence that they rely on that theory to carve up experience (Cobern, 1991; Hills, 1989; Kuhn, 1970; Toulmin, 1972). However, not one of eighteen students spontaneously addressed the question of what causes the continuing motion of either the penny, the marble, or in the third complex event, the bouncing ball. Even though all three complex events included projectile motion for which the "motion implies force" rule is applicable, and one complex event, the penny flip, is quite similar to Clement's "coin problem", these students did not once propose that a continual force must be acting in the direction of motion. Indeed, though students used the concept of force to explain distance traveled, height reached, direction traveled, or even the number of times a ball will bounce, in no case did a student use the concept of force (or strength or push) to explain the *continued* motion of an object once it was set in motion. Explaining continuing motion was simply not a concern for these students.

It may be argued that these students really do have "motion implies force" preconceptions and that the absence of questions about a continual force is not sufficient to prove the absence of the preconception. Preconceptions, the argument might go, are tacit and must be looked for. But if the preconception that continual motion requires continual force is only evident in cases where students are asked to explain continual motion (or the cessation of it), then perhaps it is not a preconception at all. It may be that there is another, more generally applicable, commitment that "for every effect, there is a cause" (Cobern, 1991; diSessa, 1988). Then, when students are asked to treat continual motion as an effect that needs explanation, they are compelled by their commitment to supply a cause — the concept of force is an obvious "causal candidate" (Gutierrez & Ogborn, 1992). If so, the apparent rule is an artefact of the research method.

METHODOLOGICAL CONCERNS

In any peer interview, the students may interact in unpredictable ways. While this is a strength of the method, it is also a potential source of difficulty. For one thing, the students clearly influence the verbiage of each other; therefore, in the case where an explanation is constructed during the conversation, it is difficult to attribute a particular conception to just one student. In this situation, the data must be carefully examined for evidence that the mutual construction is indeed mutual.

Also, all of the sociological issues which are of concern in dyadic interactions (e.g., gender-, culture-, and age-related factors) are compounded in triadic interactions. In typical researcher-subject interviews, the researcher is cognizant of these issues and takes steps to reduce their impact on the data generated. But in a peer interview situation, even though the researcher may attempt to foster an atmosphere of openness and acceptance of ideas, one or both students may subvert that effort. In one of the peer interviews the two students exhibited a competitiveness that seemed to discourage the risk-taking that is inherent to making private thoughts public. As a result, that interview was not as productive as the others.

Finally, an important limitation of the peer interview about complex events is the reduced opportunity for the researcher to probe further into a student's explanation. I limited my questions to requests for clarification (e.g., MAR - "maybe if it was a thin dip it would be able to go faster", res - "what's a *thin dip*?", MAR - "if it was straight, it's that if this part was back here . . .") or efforts at maintaining the conversation (e.g., after a long pause, "what do you think about what she just said?"). I refrained from probing more deeply into students' explanations so that the students would remain in charge of the content of the conversation. In certain cases, as when DIA said that "sometimes speed equals strength," it was difficult to refrain. I dealt with this limitation by including multiple methods in my study in an effort at triangulation (Lincoln & Guba, 1985). I was able to ask DIA, for example, to elaborate on her idea that speed equals strength in a one-to-one interview at another time.

SUMMARY AND CONCLUSION

I have described a new method for investigating students' preinstructional knowledge of mechanics called the "peer interview about complex events." The main features of the method are that it allows students to determine the events of interest and the questions to be answered as well as the explanations. This is in contrast to traditional methods of inquiry in which the events of interest and the questions to be answered are predetermined by the researcher. I have argued that use of the peer interview about complex events provides a stronger warrant for making claims about what students know than use of traditional methods. Evidence was also presented that this method reflects a new avenue for hypothesizing about students' preinstructional knowledge of mechanics and that the data generated to date call into question some previous claims regarding such knowledge. Despite the difficulties that arise from a more complex interview situation, and the limitations inherent in letting the students determine the content of the interview, the peer interview about complex events shows promise as a research tool to be used in conjunction with other methods to provide a more comprehensive picture of students' preinstructional knowledge.

This method and the research design in which it was enacted are my response to an urgent need for theoretical and methodological improvements in research into students' preinstructional knowledge. In the face of criticisms such as those by McClelland, Willson, and Phillips, the findings of much of the research that has attempted to investigate such knowledge is called into question. If the goals of this research program are worthwhile, as I believe they are, we must strive for ever more rigorous generation of knowledge claims regarding student conceptions — claims that can be defended by sound theoretical and methodological argumentation. Such rigor requires "the coherence of the relationships between correctly applied methods, legitimate warrants employed in the interpretation of data, and the soundness of the arguments established in the drafting of claims" (Lythcott & Duschl, 1990, p. 447).

Some recommendations for so improving science education research call for investigation of student conceptions in their natural context. Roth (1992) recommends that researchers strive for *ecological validity* — the idea that research contexts should lead to the same kind of observations as naturally occurring contexts. He goes on to describe "environments where students find themselves in situations of authentic practice — in situations where they are encouraged to ask their own questions, then frame problems in that context, and subsequently solve them" (p. 630). Hills (1989) calls for studies which investigate students' untutored beliefs without making the unnecessary assumption that they are, in some sense, scientific and must therefore be evaluated by the standards of science. Cobern joins Hills in this regard and recommends that student beliefs must be studied in an appropriate context:

> For example, if a researcher studies student views concerning force, the researcher will first have to fight the tendency to study the student views in relation to scientific conceptions. Instead, the proper objective is to understand student views of force as they relate to students' culturally based, general understanding of how the world works. Even then, a persistent focus on force alone obscures the context in which student ideas about force are held. (Cobern, 1991, p. 99)

The peer interview about complex events was invented specifically to generate data about students' understanding of how the world works, and to do so in a manner that is ecologically valid. This work represents an early effort at investigating students' knowledge of motion in this manner. Even at this early stage, however, the results promise an interesting new view of students' preinstructional knowledge.

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