On *Seeing* during Computer-Mediated Collaborative Learning

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Abstract: - Educators generally assume that students, presented with images, texts, video, or demonstrations, see what the curriculum designer intends them to see, that is, pick out the information, and subsequently integrate it into their existing understanding, which, because the latter has been expanded, constitutes a moment of learning. However there are indications that students do not see what they are supposed to see, which precisely inhibits them to learn what they are supposed to learn. In this study, two classroom episodes are used (a) to show how students in an advanced physics course do not see relevant information on the computer monitor, leading them to construct inappropriate theories and (b) to exemplify teaching strategies designed to allow relevant structures to become salient in students' perception allowing them to generate analogies and thereby learn.

Key-Words: - Perception, knowing, learning, computer simulations, science, adaptive teaching

1 The Ideology of Seeing

"*Now* I see!" and "I see your point" are familiar English expressions that not only indicate to the listener that the speaker sees something, here unspecified, but also that the speaker understands. Seeing not only is an analogy in everyday discourse for knowing and understanding but also has been the fundamental way in which scientists have understood how the mind and philosophy work—at least until the appearance of the critically acclaimed *Philosophy and the Mirror of Nature* [1].

Educators at all levels assume that students are presented with information when texts, images, artifacts, life demonstrations, or videos are made available to them for their inspection. Thus, scientists use demonstrations and teachers generally ask their students to use the Internet to get this or that information. But is the assumption warranted that such exposure presents students with the information that teachers think they are getting? There are both theoretical and empirical grounds on which we can ground a more cautionary stance. First, it now is generally accepted that all observation is theory-laden. If this is the case, then students who do not know, do not have a theory, or who employ (naïve) alternative theories will see something different than the very thing that educators need them to see in support of the new (correct) theory they are to learn. Students are therefore caught in a quandary where they are asked to see which requires them to know the very theory that the lesson is designed to teach them.

Second, a number of empirical studies have shown that students do not see what they are expected and need to see in a demonstration to learn the theory subsequently exposed and articulated by the teacher [2]. More so, even experienced scientists confronted with unfamiliar graphs culled from undergraduate textbooks in their own discipline frequently do not see what they need to see to provide a correct interpretation, that is, one that the course instructors of first-year courses would expect them to [3]. Such findings show that educators need to be more cautious with their assumption that students have received information and they have to begin to ask how to ascertain the nature of what students actually rather than supposedly see and the information they get (e.g., from the displays on computer monitors).

When people collaborate groups, they often articulate seeing different things—not unlike the frequently observed wide gaps that exist between the testimonies provided by different court witnesses. This possibility of different perceptions is actively exploited in collaborative learning environments (such a CSCL), as the students come to face different ways of seeing within and between groups, which allows them to grabble with the nature and source of the differences. The relevant discussions allow them working toward understanding, which sociocultural and cultural-historical theories of learning theorize first to occur at the interpsychological (social) level and subsequently at the intrapsychological (personal) level [4].

The purpose of this study is to investigate what and how students learn when they work in a collaborative setting using computer-based simulations of physical phenomena. Of special interest to this research are student–teacher interactions and how these mediate student perception, teacher assessment, and teacher intervention.

2 Research Design

This naturalistic study was designed to investigate knowing and learning in a real classroom setting where students, among many other forms of engagement, also used a computer simulation tool—Interactive Physics—to learn about Newtonian motion. In three sections of an advanced physics course for twelfth graders, groups of students were videotaped while completing a series of tasks that began with explorations of forces on the motion of objects to the design of a game for younger students.

2.1 Setting and Participants

The study was conducted in a private, British-style college-preparatory, co-ed school in Canada. The students generally were from well-to-do families, though students from lower income families attended, too, having received general or sports scholarships. The achievement levels were comparable to the local public schools. The students (*N* = 47) were enrolled in an advance-level physics course focusing on qualitative understandings of concepts. The course was designed following principles of social constructivism. For the purpose of this paper, I focus on the interaction of one group of students, involving two males (Glen, Ryan) and one female (Elizabeth). They are typical of the school population in that they all aspire to go—and since have gone—to college, though, as the predominant number of students, not into the sciences, opting instead for more lucrative careers in business and law.

2.2 Task Environment

Interactive Physics is a computer-based Newtonian microworld that allows users to conduct motion-related experiments. Observables such as force, velocity or acceleration can be made visible as vectors or represented via instruments such as strip chart recorders and digital and analog meters. All student activities in the present study included, at a minimum, one circular object (Fig. 1).

A force (full arrow) could be attached to this object by highlighting and moving it with the mouse. The object's velocity (students could modify its initial value by highlighting the object, "grabbing" the tip of the vector, and manipulating its magnitude and direction) was always displayed as a vector (line arrow). Students were asked to find out more about the microworld, especially the meaning of the arrows. The denotations "«force»" and "«velocity»" are used here as convenient way to denote force and velocity vectors whatever the students' current way of calling them.

Fig.1, Interface of Interactive Physics and typical screen display in early task configurations

2.3 Cognitive Task Analysis

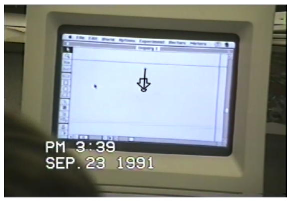
Physicists articulate the relationship between the net force $\underline{F}$ acting on an object and its velocity $\underline{v}$ in the form of

$$\underline{v}(t) = \frac{\underline{F}}{m} t + \underline{v}(t = 0) \qquad (1)$$

where m is the mass of the object, t the amount of time that the force has acted upon the object, and $\underline{v}(t=0)$ the velocity at the moment that the force has begun to act. The underbar denotes the vector nature of velocity and force, meaning that these quantities have both magnitude and direction. Thus, in considering the effect of the force on the present velocity, the relative directions of the two have to be taken into account. If, for example, the direction of force is opposite to the direction of velocity, the speed (i.e., magnitude of velocity) of the object decreases; if the two point into the same direction, the speed of object (i.e., magnitude of velocity) will increase. In Interactive Physics, the vector nature of velocity and force is implemented by means of arrows, which both have magnitude and direction. In the situation depicted in Fig. 1, the object would begin moving to the left but, accelerated by the upward pointing force, increase its speed in upward direction until, in the limit, it would move in the same direction as the force.

2.4 Data and Analyses

Conversations of three student groups over and about the Interactive Physics tasks were recorded during four one-hour periods separated by two-week intervals yielding a total of 12 hours of videotapes. The video was digitized and completely transcribed, including pauses, overlaps, and images of relevant screen displays. My analytic method is based on microsociological research on everyday work practices and human-machine interactions and conversational analysis [5]. The nature of the tasks required students and teacher to talk about the screen displays, thereby producing natural protocols of sense-in-the-making.

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50 T: see (2.48) WHAT if you had that point up? (2.93) <<p>and
      this one would point like this?> ((The teacher moves
      first «velocity» then «force» into configuration shown,
      velocity straight up, force straight down.))
51 G: it would go straight down.
52 R: yea [it would go] downward.
53 T: <<p>[okay:     ]>
54    (1.04) ((Teacher
      runs the simula-
      tion, which re-
      sults in the
      screen display de-
      picted to the
      right.))
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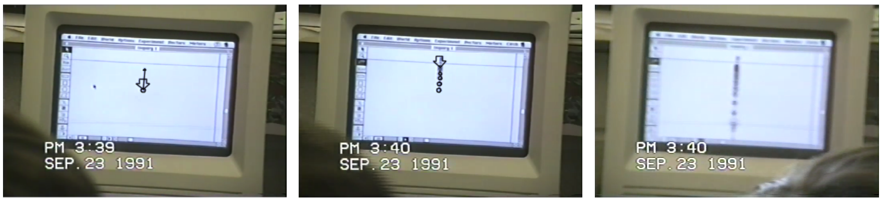


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55 E: and [a  se[E] it went backwards   ] first tho][ugh].
56 T:     [this [a]
57 R:        <<p>[i think it went upwards]>
58 T:                                                   [th-] but? (0.40) fi[rst?]
59 R:                                                                       [the ]
      initial velocity <<p>would go the way the little arrow is.>
60 E: didnit go backwards firs[t? an]d-
61 R:                         [yea  ].
62 E: then get both arrows?
63 R: i think so.
64 E: yea.
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Fig. 2, Transcript of the episode in which students come to perceive the relationship between the «velocity» and «force» vectors.

3 Learning to See

This study investigates how students come to see phenomena that they have not perceived before although opportunities have existed for this to occur. It is in the course of episodes such as the one discussed below that students come to perceive new phenomena, setting them up to learn about how to theorize them in the way the standard sciences do. Thus, in the context of their tasks doing simulations in the Interactive Physics environment, it turns out that many students do not provide observation descriptions of events suitable for understanding the theory that the events are said to provide evidence off.

3.1 Beginning the Intervention

Up to the point of the episode in the transcript (Fig.2)[1], what has happened follows the spirit of the opening query, “What have you found out so far?” The session then takes a turn. From the conversation, the teacher—as his next discursive move exhibits—evidently has not gotten the sense that students have found out what the task had asked them to. The teacher now sets up a configuration of «velocity» and «force» such that the former points straight up and the latter straight down. Inherently, there is no difference to any other configuration where the two arrows are set in opposite direction; however, this particular configuration, because it embodies the “up–down schema” grounded in the everyday experience of living in the gravitational field of the earth [6], provides the possibility of an analogy with throwing an object (such as a ball) into the air, which is then pulled to the earth by the gravitational force. Such analogies are foundational for relating new experiences to an already familiar world shot through with meaning. That is, new words, objects, and perceptual experiences accrue to meaning, allowing students to further articulate how the world works.

The teacher then engages students in an interaction in the course of which they come to describe the motion in a way consistent with the Newtonian theory that they are to learn as part of the tasks that they currently complete. The episode begins by shifting his position so that he can reach and manipulate the mouse, and with it, the objects that appear in the microworld. As he rotates «force» to point downward and «velocity» in the opposite direction, he asks students a question of the type “What happens if . . .?” (turn 50), which, as previous research has shown, is a productive question that invites students to think and spend extended amounts of time investigating [7]. For a physicist or any other person knowing about the physics of motion, it is clear that the teacher reduced the complexity of the situation because students now only consider linear rather than curved motion. More so, the specific orientation chosen is up–down. What happen when this configuration is “run” does not depend on the up–down orientation—any orientation will do. But the up–down configuration sets up the possibility of drawing a real-world analogy with throwing an object straight up into the air.

Glen immediately suggests that the circular object will go straight down, and Ryan nods and expresses agreement (turns 52, 53). This apparently reifies what may have incited the teacher to begin this demonstration in the first place, as, from a physicist's perspective, the answer is not correct; because of the initial velocity pointing upward, the object should move into that direction prior to the reversal of the velocity due to the force (see task analysis). Because the students have been working with this particular simulation for nearly 15 minutes, it is likely that these experiences have mediated what they learned so far.

3.2 Running the Simulation

The teacher's "okay" (turn 53), may confirm having heard students' hypotheses about how the object would move, but, uttered at low speech intensity, he may have been talking to himself as if confirming his hypothesis about students' current understanding. In the pause that follows, the teacher "runs" the simulation he has prepared (turn 54), yielding an event in the microworld as shown in the offprints (Fig. 2, turn 54).

We do not know what is in his head and therefore what drives his moves, that is, why he does what he does. But the students do not know this either. All they can go by is what the teacher makes available to them. However, because the teacher moves the object, there is the possibility to see significance in his action for whatever (hidden) reason. The very fact that he does engage with them may be a resource for constructing that what they have said as inappropriate. But then, the episode is unfolding so quickly that nobody really has the time to stop and think; rather, the teacher has set up this intervention within seconds and then engages students in a question–answer sequence that does not contain the frequently observed evaluation component typical in what researchers have come to denote as the initiation–response–evaluation (IRE) pattern [8].

3.3 An Alternate Observation Description

With the traces of the object positions over time displayed on the monitor—this feature of Interactive Physics works like time-laps photography—three individuals speak at the same time (turns 55–57). This is not unusual for conversations especially when there has been a pause, which is a feature that goes away only when someone speaks. The longer the pause, the more there is a social obligation (at least in Western societies) to speak—the standard maximum being of the order of one second [9]. Elizabeth notes for everyone to hear that the object has first moved upward before engaging the downward motion that Glen and Ryan previously predicted. The teacher begins but immediately stops again at about the same time that Ryan—simultaneously with Elizabeth—describes the motion as having been "upwards."

We can almost hear (and certainly in the transcript see) Elizabeth's surprise and change in orientation. She begins her utterance and in the middle of the word "see," her speech volume increases, thereby hearably drawing the attention of others to something that she has seen and that therefore can be seen generally. She stresses both the words "went" and "back," and then adds the temporal adverb "first" and the conjunctive "though." I now unpack this part of the interaction. The particle "though" is both conjunctive and an adversative particle that expresses a relation between two opposed facts or circumstances in which one of the facts is inadequate but both do occur. The utterance of "though" thereby renders the earlier descriptions (the object as moving down) as matters of fact—rather than as hypotheses in the way they have been proffered before the simulation. That is, although Ryan and Glen have made their statements prior to the simulation, their utterances now have become observation sentences. But Elizabeth's contribution constrains the applicability of the two earlier utterances, which now have become observation sentences. How? In her turn, Elizabeth provides an improved observation, "it went backwards first." That is, because "though" has conjunctive function, the current state of affairs is this: *First* it [object] went backwards and *then* it goes downward/straight down. This state of affairs is actually stabilized by events that have occurred simultaneously—Ryan also proffers an observation description, "it went upwards" (turn 57).

3.4 Confirmatory Power of Uncertainty

Although uncertainty in conversations generally creates further uncertainty, it can also be a resource for confirmation [10]. Here, Ryan prefaces his observation description by the modifier of uncertainty, "I think." It is a statement typically found very early in scientific discoveries, constituting a rhetorical move that allows for the possibility to be incorrect because of this or that contingency [11]. That is, the "I think" modifies an observation as a possibility without requiring the speaker's commitment so that he or she can easily renegue. Modifiers are used in the first stage in the social construction of scientific facts. In the present episode, the confirmation and stabilization actually occur simultaneously and for everyone to hear—it comes from Elizabeth's utterance, which articulates a compatible observation sentence precisely then when “backwards” and “upwards” are heard as denoting identical states of affairs.

My analysis appears to indicate that the issue has been settled. However—certainly because of the rate at which real time events unfold and the time it takes for human being to become aware of what has happened—the issue about the correct observation description remains open as the subsequent turns at talk show.

Overlapping the very end of Elizabeth’s talk, the teacher utters several, even unfinished but seemingly disconnected words (turn 58). The first sound “th-” terminates in a sudden stop; the second is heard as “but” with a rising inflection generally attributed to questions; then there is a pause, followed by a repetition of the “first” that Elizabeth has finished uttering precisely 1.09 seconds before—though, again, with rising inflection. The particle “but” is a conjunctive marking that some statement is to be delimited, a fact has not been considered, or an exception. Here it is uttered with rising inflection as in a question that asks students to consider something the nature of which is not evident from the talk so far. There is a 0.40-second pause, and then the teacher repeats the temporal adverb “first?” with rising inflection (turn 58). These rising inflections allow the words to be heard as elliptic forms of the question, “But what has happened first?” That is, in this case the teacher asks the question to which Elizabeth and Ryan have already provided the answer. This raises two issues.

First, the appearance of this question at precisely this point is not surprising when we consider that even experienced Tetris players would require more than 1.2 seconds to become conscious of an object on the screen and to reflect on the next move [12]. Here, the teacher’s utterance comes about faster than it would take for simple objects to be processed in mind. This speed has to be considered in the light of the fact that Tetris players are familiar with the objects that may appear, whereas the teacher is in an entirely novel, once-occurrent situation.

Second, the fact that the teacher raises an admittedly indeterminate question can be interpreted by other participants that something requires further talk, that is, that the answer provided so far still is insufficient to answer the larger question about what has happened in this simulation.

Ryan immediately responds suggesting that the initial velocity “would” go in the direction of the little arrow. It is not certain which arrow he signifies, because, as my analyses show, these students use the same term for both arrows and without apparently being aware of the fact that in any one situation, two speakers may use the same signifier to signify different arrows. In the present case, «force» is the shorter arrow whereas «velocity» is skinnier but longer. It therefore comes as no surprise that Elizabeth raises the question opposition, “didn’t it go backwards first?” Whatever Ryan has wanted to say, Elizabeth has heard it as an observation description that opposes her own. That is, whereas she has earlier described the object as moving “backwards,” her present statement exhibits that she understands Ryan to have reconfirmed his initial description according to which the object “goes downward.”

3.5 Closing Uncertainty

Before Elizabeth has ended, Ryan already articulates agreement with her (turn 61). They finish this episode with elliptical utterances but in apparent agreement. Following her conjunctive “and,” Elizabeth queries—as indicated by the rising pitch toward the end—whether they would “then get both arrows.” With the compound sentence produced by the conjunctive “and,” Elizabeth raises the question whether the object “goes backwards first and then get both arrows.” A possible hearing is that after the having moved “backward first,” both arrows would point in the same direction because the object moves in the direction Ryan has indicated (i.e., downward). Ryan confirms, though with the qualifier “I think so,” and Elizabeth concludes with an affirmative “yea.”

As the subsequent conversation shows—not reproduced here—the teacher accepts what the students have formulated, as evidenced in his didactic move to allow students to link this phenomenon to some phenomenon in the real world. That is, although one can possibly read this transcript as not having settled the issues, the teacher, in going on, also declares it as settled, and therefore, as having satisfactorily answered his question.

Looking back over the episode, we note that initially observation statements—the legitimacy of which may have been grounded in students’ prior experiences with the software—come to be questioned after the teacher has run a particular simulation. Elizabeth and Ryan—in contrast to what he has just said—raise the possibility that the object has moved upward prior to moving in the way the two male students said it would happen before the simulation was run. In the course of several utterances that raise an alternative observation description as a possibility, at least two of the three students eventually make affirmative statements, which turn out to terminate the episode.

4 Conclusion

This extended analysis shows that even in the simplest of displays—two arrows changing as an object moves—students may not perceive those features and relations that are essential for understanding introductory physics. In this study, the participating students attended an elite school where 99 percent subsequently go to college and university. As a whole, this episode exemplifies my general observation in this and other databases that students do not "extract information" from whatever is available on the computer monitor, in hands-on experiments of their own design, or in teacher demonstrations [13]. That is, although the three students in this episode have run such simulations before, it is at precisely *this* moment that they first articulate the observation description that is required by and consistent with the Newtonian perspective that their physics course is designed to teach them. Initially the observation description—which in fact tells others not only what is there but also what to look for—is inconsistent with standard physics and with what the teacher can see and knows to be there. This and other studies with similar results therefore seriously question the assumptions underlying dominant practices and assumptions in science education particularly but in all of education more generally.

The data presented here also show that the teacher can be an essential element in overcoming the chicken-and-egg situation whereby students have to know the theory in order to see, but what they are asked to see is supposed to help them learn the theory. Ultimately, teacher talk would not be so much different than other forms of presenting students with text if it were not for the adaptability of human beings to the contingencies of the setting in which they are constitutive participants. So while the difficulty inherent in any form of communication is not overcome in and by the teacher presence, the latter provides opportunities for adaptive assessment and intervention. Because such assessment and intervention emerge on the spot, based on the teacher's sense of the game, the processes are themselves error prone, though both become increasingly reliable with the experience of the teacher.

This study also undermines the claims some researchers make about the usefulness of group work. Even if students work collaboratively, there is no guarantee that their different perceptions—if any—will allow them to isolate the one necessary to learn. In the example presented, two students at least apparently had extracted the same conclusion from their previous experiences with the microworld events—the ball would immediately drop rather than rise before falling, despite the fact that there was an initial upward velocity vector (arrow). More so, in this situation as elsewhere in this group as well as in other groups, the students use the same words to signify different things without becoming aware of these differences, leading to an unnoticed breakdown in their sense-making processes. Again, the collaborative work is no guarantee that the perceptual and denotation-related problems come to be known and even less to be overcome.

Notes

1. Consistent with the conventions in conversation analysis, the following transcription conventions are used: WHAT – caps indicate louder speech; (0.40) – pauses in seconds; ((moves)) – transcriber's comments; <<p> go> – piano, low speech volume; <u>then</u> – underline indicate stressed syllables; [the] – brackets indicate overlapped speech; .,;? – punctuation denotes direction of pitch as in statements, questions, clauses; - – dash denotes sudden stop; : – colons denote lengthening of phoneme.

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