From Computational Artifact to Cognitive Artifact: A Micro-ethnographic Analysis of Students Building Collaborative Knowing about a Rocket Simulation

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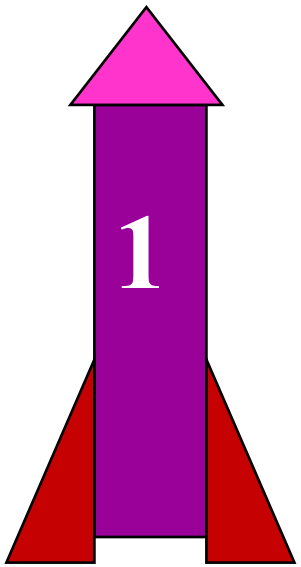
A presentation at Ethnography in Education, February 28, 2003

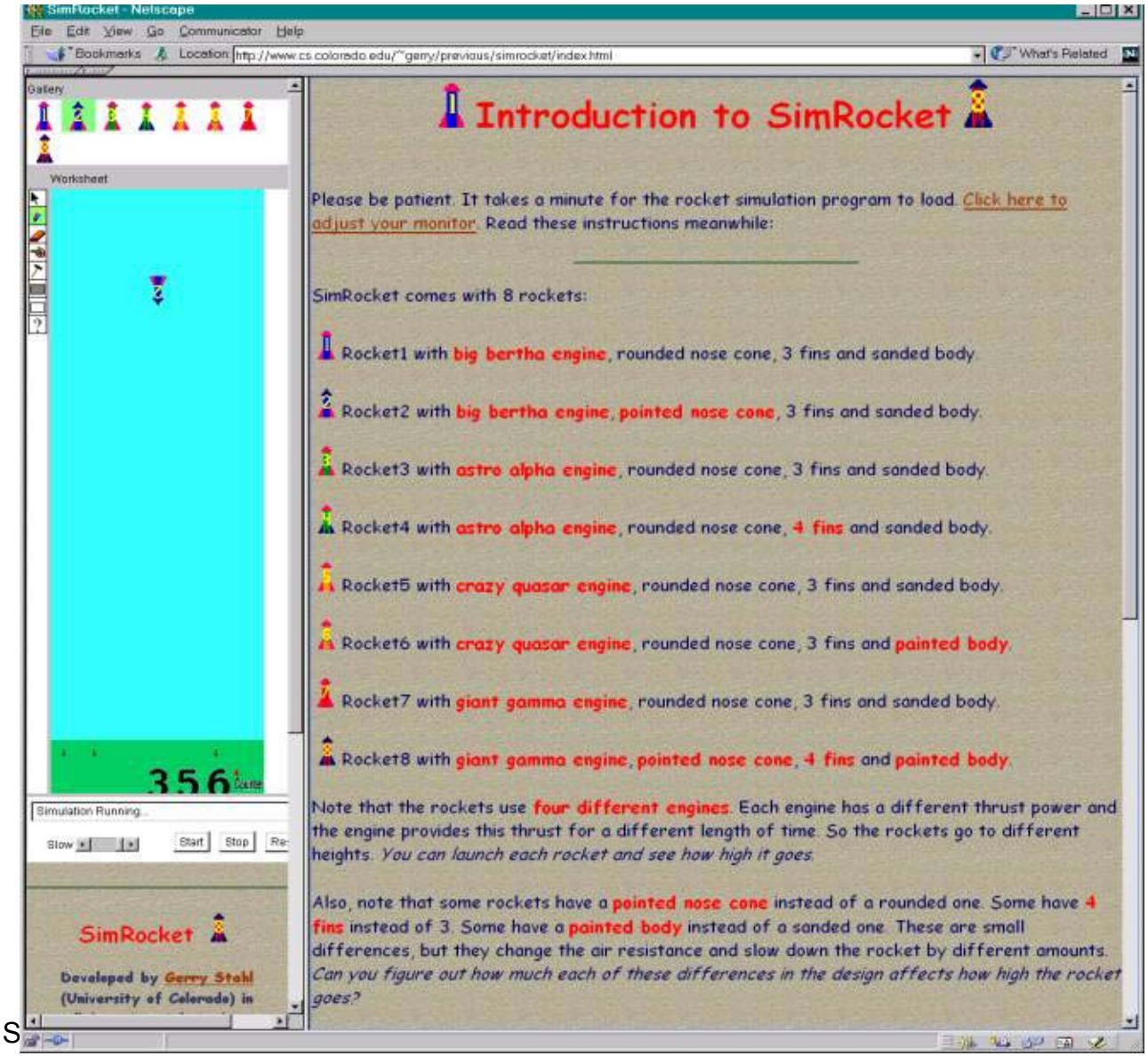


Part I.
A set of artifacts that define a knowledge-building activity
(4 artifacts that emerged from the analysis)

Experimental design

- **5 boys in 7th grade model rocket project at a local middle school**
- **2 computers with the same SimRocket software & a printed data form**
- **A tutor/coach/facilitator/teacher for two 1½ hour videotaped sessions**

Artifact 1: a rocket simulation



Artifact 2: a scientific task

You can launch each rocket and see how high it goes.

Also, note that some rockets have a **pointed nose cone** instead of a rounded one. Some have **4 fins** instead of 3. Some have a **painted body** instead of a sanded one. These are small differences, but they change the air resistance and slow down the rocket by different amounts. *Can you figure out how much each of these differences in the design affects how high the rocket goes?*

Artifact 3: a list of rockets

Introduction to SimRocket

Please be patient. It takes a minute for the rocket simulation program to load. Click here to adjust your monitor. Read these instructions meanwhile:

SimRocket comes with 8 rockets:

- Rocket1 with **big bertha engine**, rounded nose cone, 3 fins and sanded body.
- Rocket2 with **big bertha engine**, **pointed nose cone**, 3 fins and sanded body.
- Rocket3 with **astro alpha engine**, rounded nose cone, 3 fins and sanded body.
- Rocket4 with **astro alpha engine**, rounded nose cone, **4 fins** and sanded body.
- Rocket5 with **crazy quasar engine**, rounded nose cone, 3 fins and sanded body.
- Rocket6 with **crazy quasar engine**, rounded nose cone, 3 fins and **painted body**.
- Rocket7 with **giant gamma engine**, rounded nose cone, 3 fins and sanded body.
- Rocket8 with **giant gamma engine**, **pointed nose cone**, **4 fins** and **painted body**.

Note that the rockets use **four different engines**. Each engine has a different thrust power and the engine provides this thrust for a different length of time. So the rockets go to different heights. *You can launch each rocket and see how high it goes.*

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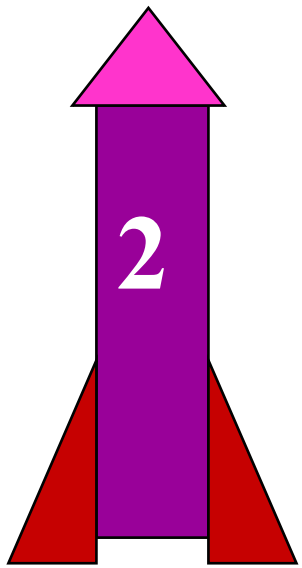
Artifact 4: a datasheet of rocket heights

Datasheet for SimRocket launches						
	launch 1	launch 2	launch 3	launch 4	launch 5	launch 6
rocket 1	383	363	364	363	364	363
rocket 2	364	340	353	361	363	360
rocket 3	400	370	398	385	390	390
rocket 4	365	370	390	370	365	370
rocket 5	270	278				
rocket 6	270	277				
rocket 7	305	325				
rocket 8						

Part II.
Students collaboratively construct how to use the list – a key artifact – to decide what kind of nose cone is best



(10 stages through which knowledge-building is interactionally achieved)

Stage a. Chuck says to take the nose cone of the one highest rocket, not recognizing that another feature could have caused that rocket to go the highest.

- **C: We'll just go with number one uh (.) an that did the best, (.) or something, out of all ours compa:red, (.) . 'r sump'n (.) then we might wanta stick that (.) with what- (.) features it had, ... to see what we wanna add to our rocket to make it go.**

- [SimRocket tape A 1:17:01 – 1:17:31]

Stage b. Steven also says to take the nose cone of the <u>one</u> highest rocket, still restating the starting approach of the students.

- **S: Well we'd look at- (.) we'd look at the <u>graph</u> that we do an see which has ⌈(uh) the ↑<u>best</u> ⌉**
- **C: ⌊which has the ⌋pointier nose**
- **S: An whichever has the ↑best like rocket one two n three or- so on, (.) .h n whichever has the best we'd look to see if it has a rounded, or a pointed, which (.) which ours shows so far, that a ↑rounded, (.) that a ↑rounded is better?**

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[SimRocket tape A 1:17:44 – 1:17:51]

Stage c. Jamie says to see whether the group with pointed nose cones is better than the group with rounded nose cones, assuming this will somehow cancel the effects of the other features.

- **J: Well what you do is you take every one that has a rounded nose an every one with a (.) pointed nose. (0.4) an you see which (0.2) one did better overall**
  - [SimRocket tape A 1:18:29 – 1:18:37]

Stage d. Chuck says to manipulate 1 feature at a time on a physical model rocket, recognizing implicitly the need to vary just 1 feature and hold the others constant.

- **C: Yeah if you could bring in one that (.) like two two liter pop bottles you know that's (.) make one with a ↑pointed nosecone n one with a ↑rounded nosecone=**
- **T: =right=**
- **C: an see which one did better .hh so then we c'd go with that one an then add the feature that was on that one to the other one .hh an whatever features you put on here, (.) you leave off of (1.0) that- uh off of the other one .hh that way you c'n j's see which one will fly. (.) 'F the features on this one didn' work then we take th'm off and then go from there.**

[SimRocket tape A 1:18:36 – 1:18:51]

Stage e. Jamie says to weight which features did better over all; Chuck contributes; Brent nods agreement – coming back to trying to use the simulation and somehow canceling the other functions.

- **J: You can use the simulation by .h finding out (.) j'st which one has a rounded nose and which one has a pointed nose? (.) and which one did better overall. (0.8) Like w- (.) which (.) rockets like (.) if (.) only one rocket with a rounded nose .h did good, then (.) a rounded nose (.) isn't very good, (.) but like if=**
- **C: =compared to the (.) pointed noses=**
- **J: yeah but like if all the rounded noses are good, (.) compared to the pointed nose, then the rounded nose- noses are good.**
- **B: ( ) ((nods agreement))**

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[SimRocket tape A 1:19:05 – 1:19:35]

Stage f. Chuck compares rockets 3 and 4 for fins, solving the problem for fins.

- **T: So how would you find out which is better four fins or three fins. (1.0)**
- **C: By launching ( ) with two different things on it–**
- **T: –Which one – which two.**
- **C: one with fou::r (.) n one with three: like (0.6) rocket four an rocket one. (0.8) Err no – (.) Ro:cke:ts, (.) fou:r, n rocket three. Cuz they both have the same engine. (0.8) An they both have the same nosecones.**

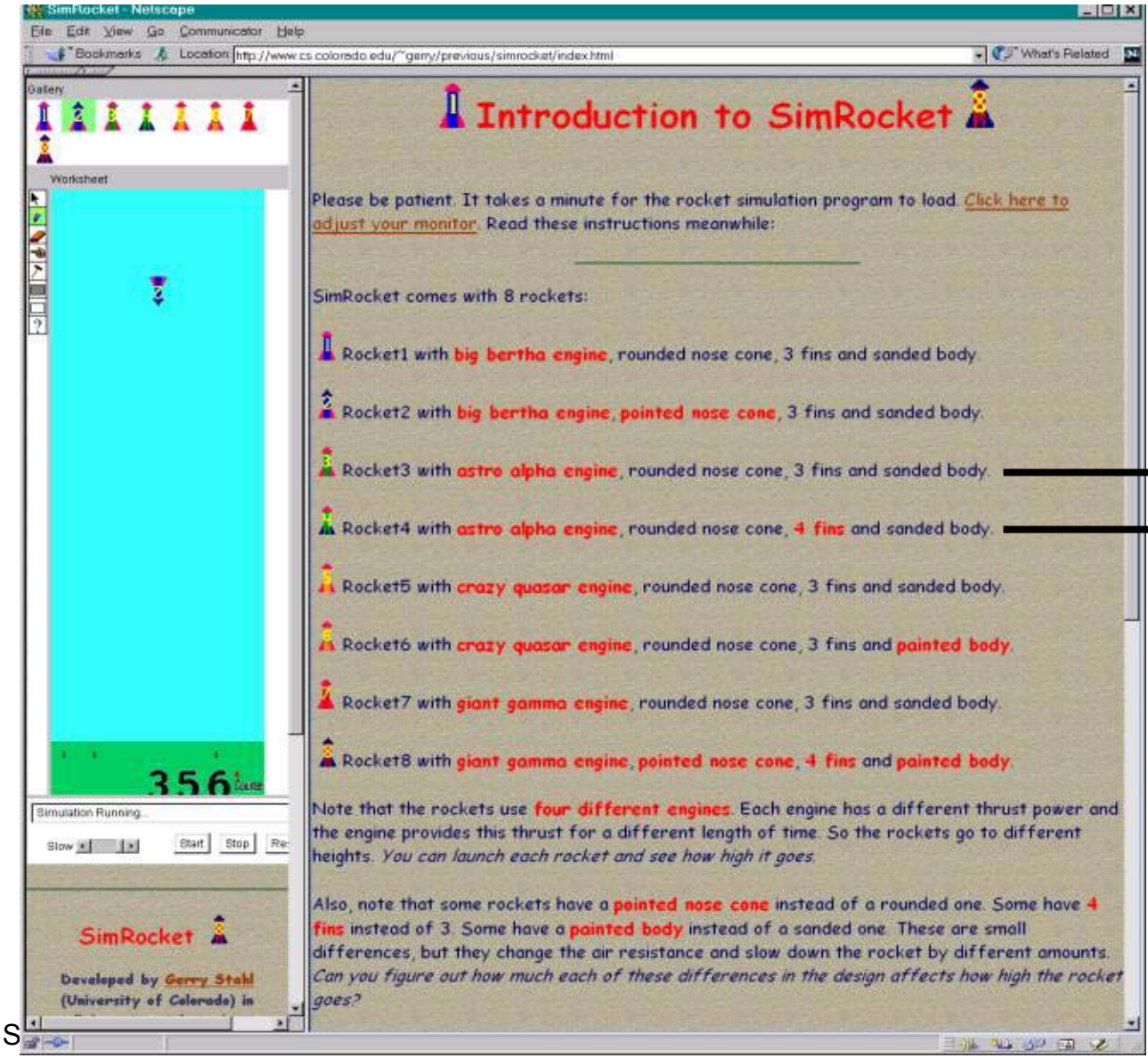
[SimRocket tape A 1:20:30 – 1:20:50]

Stage g. Chuck wants to change a simulation rocket's features to compare for nose cones, not seeing that a pair already exists for comparing nose cones.

- **C: see 'f you guys c'd make one .h wha– with an astro (.) alpha engine four fins and pointed nosecone, (1.6) w'll see if you c'd do, (.) uh cha:nge all this around n stuff so that .hh you might get ( ) you also – .hh have an option of a pointed nosecone like – ((swallow)) .hh you could (.) kinda like in HyperStudio .hh if you were tuh (.) like (.) click on this .h it would give you (.) all kinds of things th't you (.) ought – like (.) on the (.) pointy nosecone (.) .h you c'd switch it to a rounded nosecone .h and the fins,**

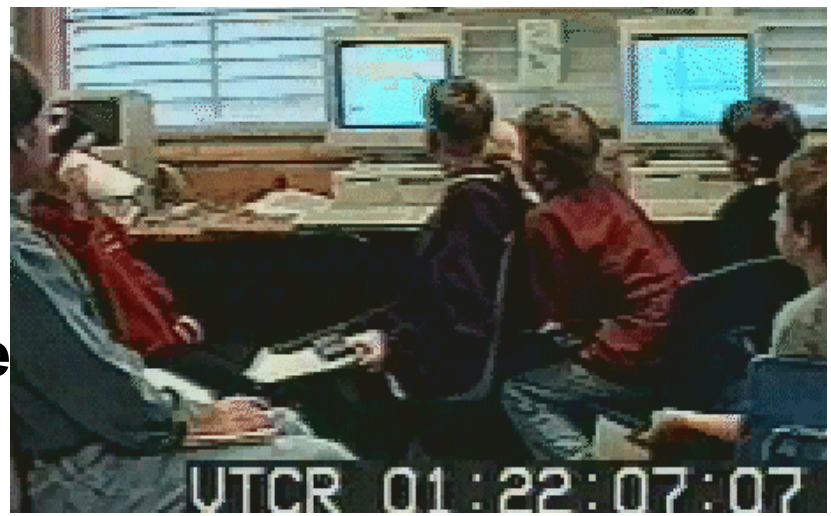
[SimRocket tape A 1:20:03 – 1:20:23]

Artifact 1: a rocket simulation



Stage h. Brent and Jamie point to rockets 1 and 2 for nose cone comparison, solving the problem for nose cones.

- **C: these are both (0.2) the same thing**
- **T: aw right–**
- **B: This one is different ((gestures with pen at monitor))**
- **J: Yeah but it has – uh**
- **C: a pointy nosecone–**
- **S: –oh yeah –**
- **C: but it's not the same**
- **J: Yeah it is,–**
- **B: –Yes it is**
- **J: Compare two n one.**

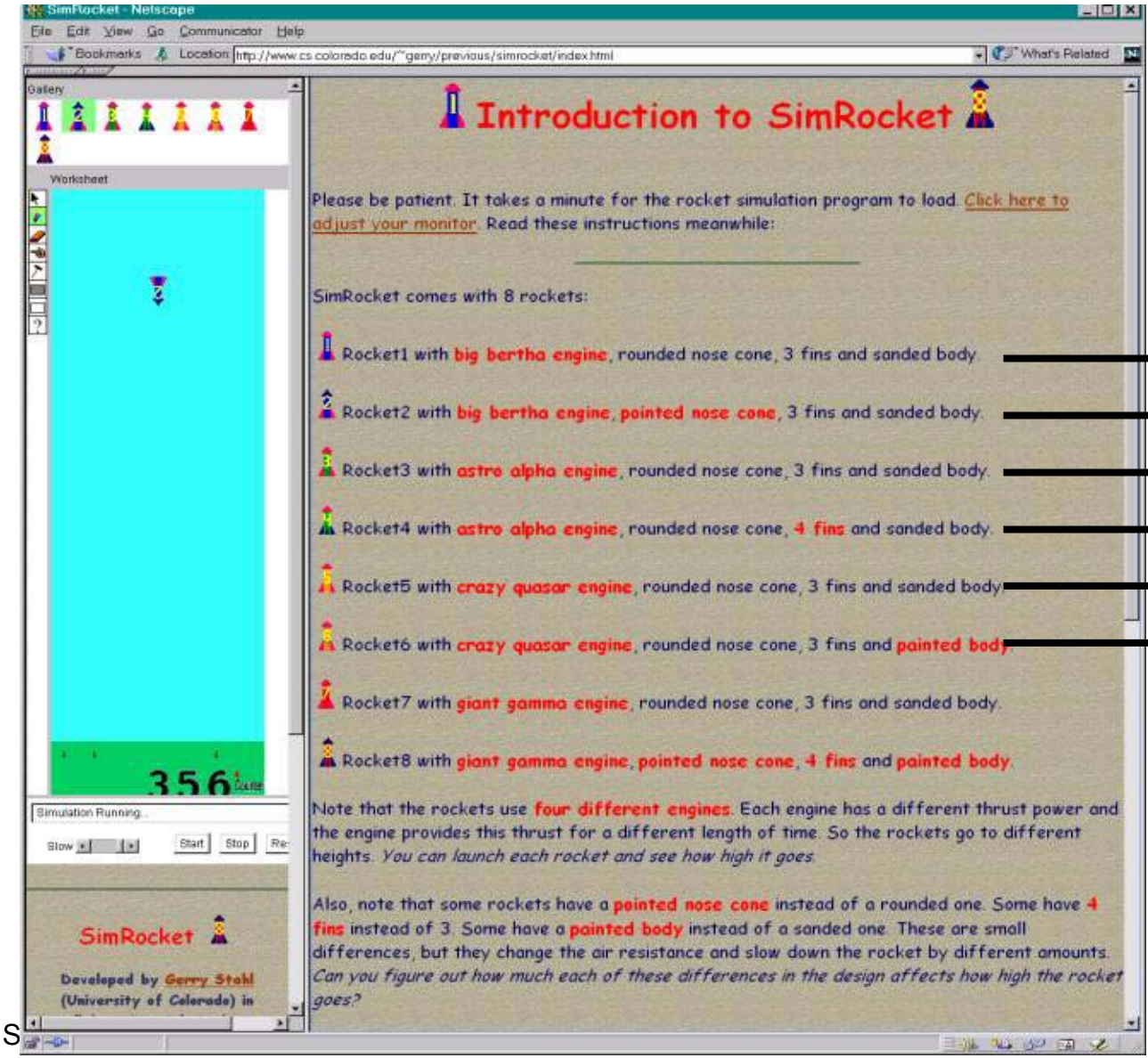


[SimRocket tape A 1:22:03 – 1:22:10]

Stage i. Steven explains the structure of the list for doing the task, solving the problem for all features.

- **T: W'll I mean what- what rocket would you design (.) in order to test (.) whether three fins is better than four.=**
- **S: =What we would do is test (.) test (.) uh- rocket three and rocket four, (.) cuz they both have a rounded nose they both (.) have that astro alpha engine n they- (.) n one has three one has four fins. I think it's good how it is because .hh every rocket has somep'n different. Like if you tested (.) five and six, then it- (.) they have the crazy uh- (.) quasar engine, .h they both have the crazy quasar engine, they both have the rounded .h nose they both have three fins, except th't if- if we uh- if we tested those two, we'd be - testing for thuh- uh painted body or uh-=**
- **T: =Uh huh=**
- **S: = a sanded body, (.) so I like it how it is.**
- [SimRocket tape A 1:24:46 – 1:25:35]

Seeing the artifact affordance

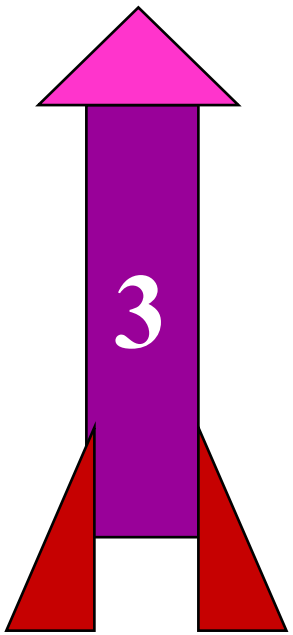


Stage j. Chuck agrees with the others, establishing group shared understanding of how to use the artifacts to solve the problem.

- **B: I would say that ⌈three is better than four**
- **J: ⌊three is better than four ( )=**
- **C: Yeah, three is better than four so=**
- **T: =So ⌈your rocket⌉**
- **C: ⌊(we want) ⌋ three fins ºn aº rounded nose⌈ cone**
- **T: ⌊Your rocket three goes up higher ‘n rocket four=**
- **Ss: Yeah ((multiple voices))**
- **T: So that means that three fins is better ‘n four.**

- [SimRocket tape A 1:26:46 – 1:27:06]

Part III.
A micro-analysis of collaboration



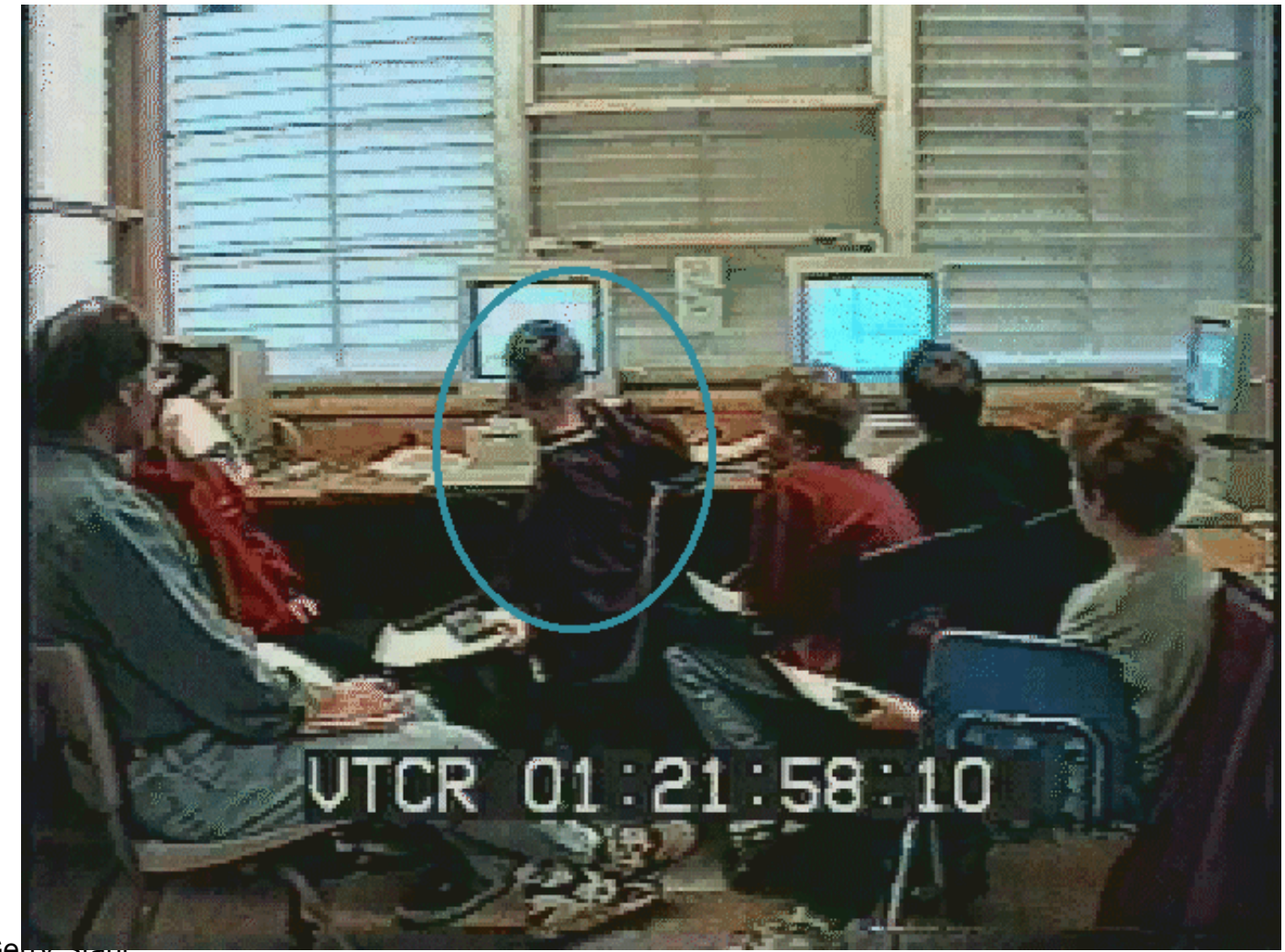
Phase A. Group focuses on Chuck's personal opinion as a reaction to Teacher's *aporia*. Interaction between Chuck and Teacher provides group focus.

Phase B. Teacher's gesture shifts focus to list artifact. Students disagree – signal need for repair.

TIME	*SPEAKER*	*VERBAL CONTENT*
1:21:53	*Teacher*	*And (.) you don't have anything like that there?*
1:21:55		*(2.0)*
1:21:56	*Steven*	*I don't think so*
1:21:57	*Jamie*	*Not with the same engine*
1:21:58	*Steven*	*[No*
	Jamie	*[Not with the same*

- **Note that every utterance here is negative – students rarely argue against the Teacher – they are displaying lack of shared understanding. The first student utterance is hedged enough to allow others to state their remarks quickly.**

Phase C. Students orient to list. Chuck struggles to hold floor.



1:21:59	*Teacher*	*With the same engine*
1:22:00	*Teacher*	*but with a different (.)*
1:22:01	*Teacher*	*nose cone?*
	Chuck	*The same*
	Jamie	*Yeah,*
1:22:02	*Chuck*	*These are both (0.8)*
		the same thing

- **Teacher repeats Jamie's "with the same engine" – but repairs misunderstanding of comparison on list (deleting "Not"). Chuck takes up "same" as a shared linguistic artifact, but does not get very far with it.**

Phase D. Brent enters central focus by thrusting forward to Chuck's computer. Brent & Jamie argue against Chuck. Steven pursues in parallel on his own.

1:22:04	*Teacher*	*(1.0) Aw [right*
1:22:05	*Brent*	*[This one's different*
1:22:06	*Jamie*	*Yeah, but it has same no….*
1:22:07		*(1.0)*
1:22:08	*Chuck*	*Pointy nose cone*
1:22:09	*Steven*	*Oh, yeah*
1:22:10	*Chuck*	*But, it's not the same engine*
1:22:11	*Jamie*	*Yeah, it is =*
1:22:12	*Brent*	*= Yes it is*
1:22:13	*Jamie*	*[Compare two 'n' one*
	Brent	*[Number two (0.2)*

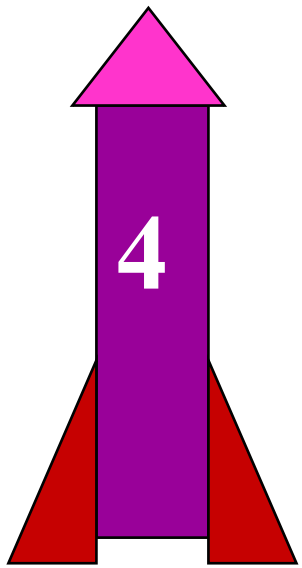
- **Teacher refuses to intervene (1.0); encourages students to work it out. Here most utterances are positive. "Same" clarified vs. "different" and applied to engine.**

Phase E. Chuck repeatedly concedes in response to Brent & Jamie's arguments. Jamie orients to data sheet and draws conclusion while others still orient to list for comparison. Kelly reflects concentrated focus of group.

1:22:14	*Chuck*	*I know (0.2)*
1:22:15	*Jamie*	*Are the same*
1:22:16	*Chuck*	*Oh*
1:22:17	*Brent*	*It's the same engine*
1:22:18	*Jamie*	*So if you ┌ compare two 'n' one*
1:22:19	*Chuck*	*└ Oh yeah, I see, I see, I….*
1:22:20		*(0.8)*
1:22:21	*Jamie*	*Yeah. Compare two 'n' one. So that the rounded n- (.) no the rounded one is better. Number one.*

- **Students display shared understanding and state it explicitly. Chuck concedes. Jamie & Brent agree. Steven has already agreed. Kelly physically aligns.**

Part IV.
From computational artifact to cognitive artifact



- **Breakdown in shared understanding – social norms of classroom contradicted by students answering in negative to teacher's hypothetical question.**
- **Teacher's references to something "like that" "there" not understood the same.**
- **Teacher explicated his terms; students try to start using them.**
- **Gestures & discourse create a shared focus on the artifact.**
- **Explicit references ("two and one") repair indexing problem.**
- **The affordance of the artifact is internalized by the group as a cognitive artifact, as deep understanding.**

- **A symbol or sign usually indexes a single object. Here, the teacher's "like that" references a relationship of "same characteristics (including "engine"), but different focal characteristic ("nose cone").**
- **To repair this, pointing is not enough. The group contributes to identify the referenced relationship ("one and two") and to align ("Ok") with perceiving the artifact's affordance ("I see") and using it.**

For further info:

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