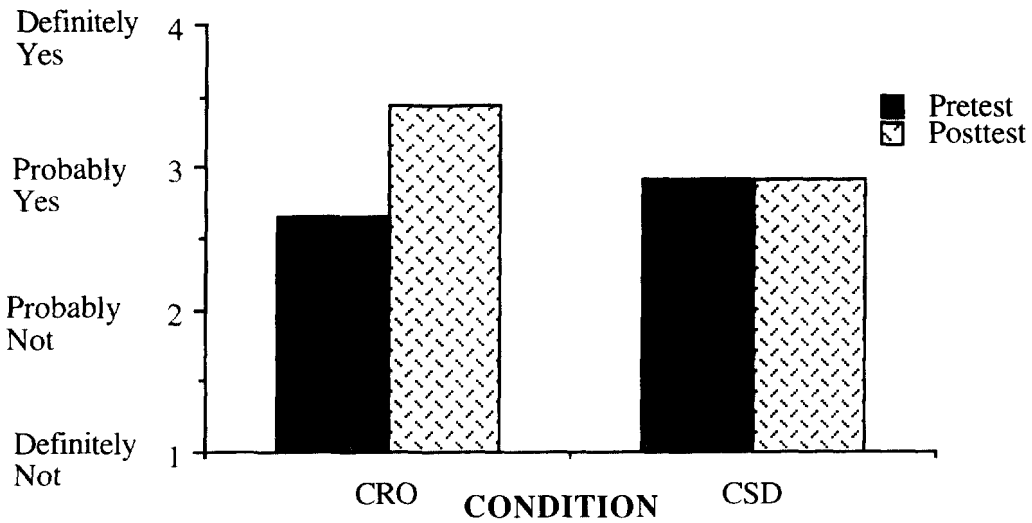

Figure 3. Interest in Viewing *CRO* Pretest vs. Posttest

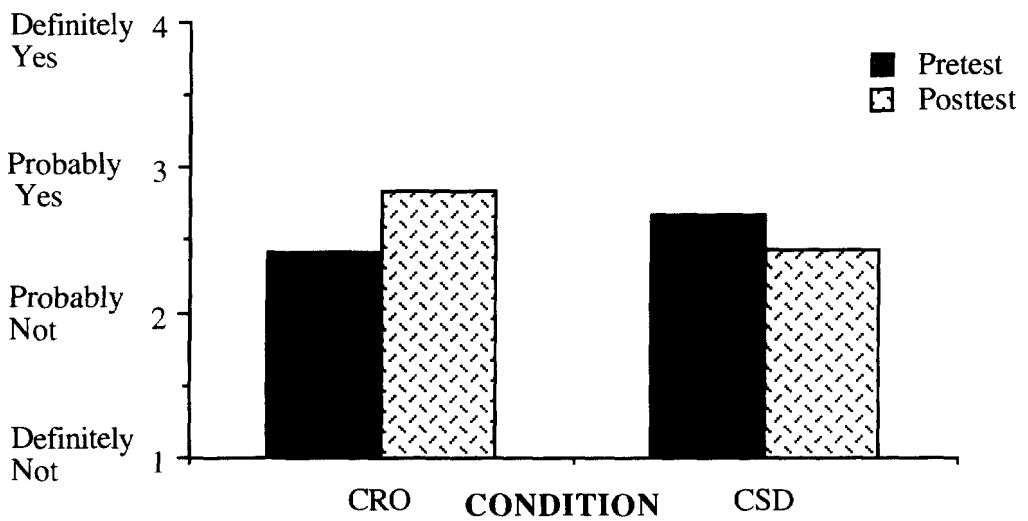

Figure 4. Interest in Viewing *Bill Nye the Science Guy* & *Beakman's World* Pretest vs. Posttest

Interest in Doing Technology and Non-Technology Activities

In this section we examine whether viewing *CRO* affected children's interest in doing technology activities related to the topics covered in *CRO* and whether it affected their physical participation in *CRO*-related activities. To examine *CRO* 's effect on children's reported

interest we compared children's interest ratings before and after treatment on two paper-and-pencil measures: 1) Learning & Doing Interest [3] and 2) Club Interest. To complement the self-report interest ratings, we also examined their pretest interest in the activities available during the activity period (as measured by the baseline measure of activity interest) and their participation in these activities during the activity period.

Interest in Doing Activities at Pretest and Posttest

Children's paper-and-pencil interest ratings for doing *CRO*-related activities (i.e., activities based on technology illustrated in the *CRO* episodes) were compared with their ratings of two other types of activities: Non-*CRO* Technology activities (activities based on technology not presented in any Season II *CRO* episode; for example, flying machines and levers), and Non-Technology activities (e.g., printing photographs, collecting coins).

Figure 5 shows children's interest for all three types of activities on the pretest and posttest assessment. Prior to the study, children in both groups rated all three types of activities as equally interesting. However, after the study the *CRO*-group showed a significant increase in their ratings for *CRO* -related activities, whereas the *CSD*-group did not ($p < .02$). For both groups, interest in Non-Technology and Non-*CRO* technology activities showed no overall change.

The impact of *CRO* on children's interest in doing *CRO*-related activities was significant for boys ($p < .005$): boys in the *CRO*-group showed an increase in interest on the posttest, whereas boys in the *CSD*-group showed a decrease in interest. Although a comparison of the girls in the two groups revealed the same pattern, the difference was not significant. This

---

[3] As noted earlier, this measure consisted of two types of items: questions to assess interest in learning about a particular topic and questions to assess interest in doing an activity. This section focuses only on the latter. The other set of items will be discussed later.

gender effect is consistent with previous research that suggests that boys are more likely to engage in science-related activities than girls even when their attitudes towards the topics linked to these activities are similar.

Within science achievement, *CRO* had the strongest positive impact on the average science achievers ($p < .05$), the subset of children in both groups who initially had the lowest interest in these activities. Although it is unclear why average science achievers initially had lower interest in engaging in *CRO*-related activities, the important finding is that *CRO* positively affected the interest of these "low-interest" children. One could speculate that these children had already begun to lose interest in science and technology and that *CRO* was a successful intervention for stopping or reversing this trend.

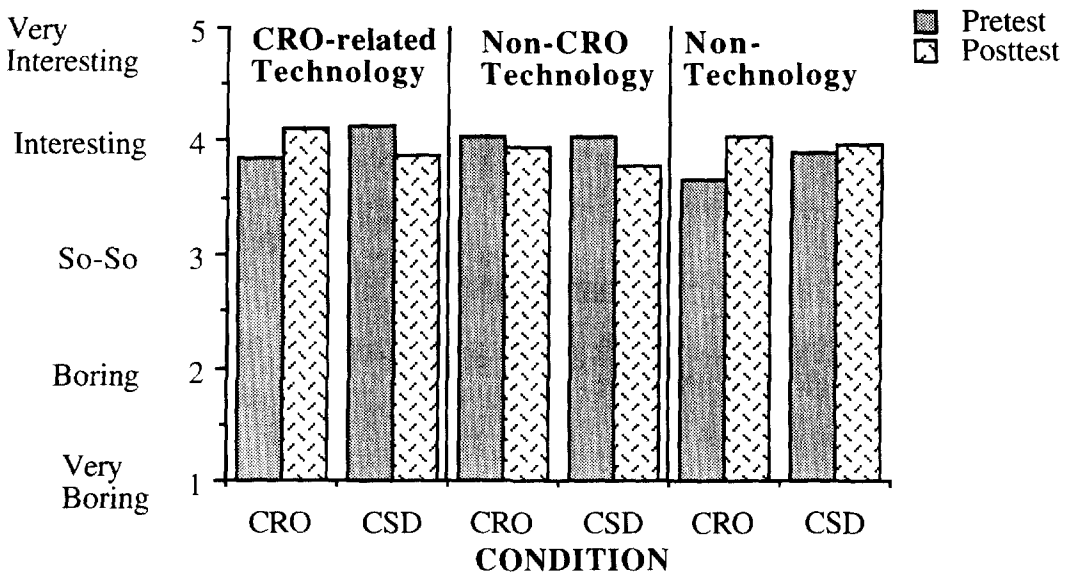

Figure 5. Interest in Doing *CRO*-Related, Non-*CRO* Technology & Non-Technology Activities Pretest vs. Posttest

Interest in Joining *CRO*-related and Control Clubs at Pretest and Posttest

Figure 6 shows children's interest in joining *CRO*-related clubs (Scientists' and Inventors' Clubs) and Control clubs (e.g., Homework Club, Music Club) at pretest and posttest. No significant differences were found between the *CRO*- and *CSD*-groups. For both groups,

CRO-related clubs were rated higher than the control clubs at pretest and posttest. This was due to boys in both groups showing a higher interest in *CRO*-related clubs than control clubs and girls in both groups showing an equal interest in both types of clubs.

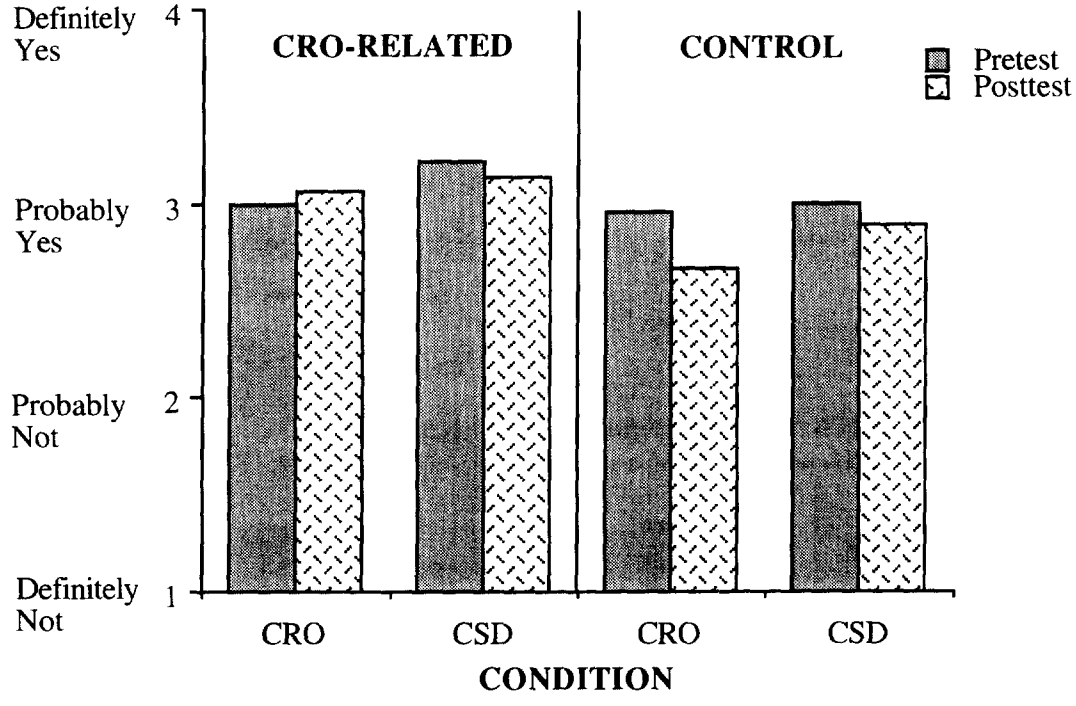

Figure 6. Interest in Joining *CRO*-Related (Scientists' & Inventors') Clubs & Control Clubs Pretest vs. Posttest

Children were also asked to select the one club that they most and least wanted to join. Again, the *CRO*- and *CSD*-groups did not differ significantly.

The individual club ratings and the Most and Least preferences revealed inconsistencies, which point to possible problems with the validity of these measures. Nine percent of the children selected one club as their favorite but gave a higher interest rating to a different club. Similarly, 23% of the children rated their least favorite club higher than another club. The inconsistencies were significantly more prevalent in the Least Likely questions than the Most Likely questions, $p < .001$. We suspect that some of the difficulty was due to comprehension

problems, specifically with the term "least." Children often asked what least meant, and some seemed to interpret "least likely" as meaning "second favorite."

Our observations also suggest that general labels, such as "Scientist," "Writer," or "Garden," are ambiguous for children. Most children did not know what the clubs referred to and before endorsing a club they wanted to know what specific activities were involved. For example, some children asked whether the music club would involve listening to music or playing a musical instrument, and indicated their rating would depend on the specific activity. This strongly supports the need for using specific and concrete assessment items, especially for children, who may lack the real-world experience to assign a meaning to more general labels.

Baseline Hands-on Activities Interest Ratings

Prior to treatment, children rated their interest in playing with the different toys and computer games available in the activity period. Overall, children rated the activities as interesting, and there were no significant differences in interest ratings between the *CRO*- and *CSD*-groups for activity topic (*CRO*-related, Non-*CRO* Technology , Non-Technology), or activity type (computer games and toys). Thus, there were no differences between groups in their attraction to these activities prior to the treatment.

However, boys and girls rated the activity topics differently, $p < .01$. Boys rated the *CRO*-related and Non-*CRO* Technology activities higher than the Non-Technology activities, whereas girls rated Non-Technology activities higher than both Non-*CRO* Technology and *CRO*-related activities.

Hands-on Activities: Children's Activity Choices during Activity Period

In this section, we discuss the impact of *CRO* on children's hands-on behavior during the activity periods. Specifically, we were interested in whether exposure to *CRO* would lead children to engage in *CRO*-related technology activities over other, Non-Technology

activities.

We approached this analysis in two ways. First, we examined the degree to which the *CRO*- and *CSD*-groups engaged in individual activities that were related to the topics covered in specific episodes of *CRO*. Next, we assessed the degree to which the *CRO*- and *CSD*-groups engaged in any *CRO*-related activities in each activity period.

Specific Activities

Tables 5 and 6 show the percentage of children in the *CRO*- and *CSD*-groups who engaged in *CRO*-specific and *CRO*-general activities on each activity day.[4] Several significant effects pointed to the impact of *CRO*. Children in the *CRO*-group were the only ones who chose to engage in the timekeeper activity, $p < .01$. In addition, the *CRO*-group showed a significant increase in the degree to which they engaged in the belts and wheels activity after viewing an episode on Wheels and Belts, $p < .05$; moreover, they chose this activity significantly more often than the *CSD*-group ($p < .05$) after viewing the related episode of *CRO*.

[4] There were no activities available that related to Mirrors and Periscopes, Heat and Insulation, or Buoyancy and so these are deleted from the analysis.

Activity Selected	After Viewing *CRO* Episodes on:			
	Mirrors & Periscopes (n=46)	Catapults Windmills (n=40)	Belts & Wheels (n= 40)	Timekeepers Traps & Triggers (n=37)
Catapults Windmills	34	**55**	28	11
Belts & Wheels	29	13	**53**	33
Timekeepers Traps & Triggers	32	35	45	**35**

Table 5. Percent of Children in the *CRO*-Group Engaging in *CRO*-specific (shaded cells) and *CRO*-general Activities by Activity Day

Activity Selected	After Viewing *CSD* Episodes on:			
	Music UFO's (n=43)	Art Cats (n=38)	Dinosaurs Chess (n=36)	Children's Literature Low-Tech Challenge (n=34)
Catapults Windmills	36	**41**	19	30
Belts & Wheels	34	26	**6**	21
Timekeepers Traps & Triggers	25	21	36	**26**

Table 6. Percent of Children in the *CSD*-Group Engaging in *CRO*-specific (shaded cells) and *CRO*-general Activities by Activity Day

Overall trends

In the next analysis, we compared the degree to which the *CRO*- and *CSD*-groups engaged in the *CRO*-related activities as a proportion of all the activities combined for each activity period. That is, of all the activities that were chosen in each group on a particular day, how many were related to *CRO*?

As shown in Figure 7, the *CRO*-group's proportion of activities that were *CRO*-related remained relatively constant across the four days. By contrast, the *CSD*-group showed a significant decline in the degree to which they chose the *CRO*-related activities, $p < .05$; instead, they were significantly more likely to engage in Non-Technology activities on the third and fourth day, $p < .05$. Thus, children in the *CRO*-group maintained their interest in playing with the *CRO*-related toys across the four activity periods whereas children in the *CSD*-group began to lose interest in playing with *CRO*-related toys and games and began to choose the Non-Technology toys and games more frequently.

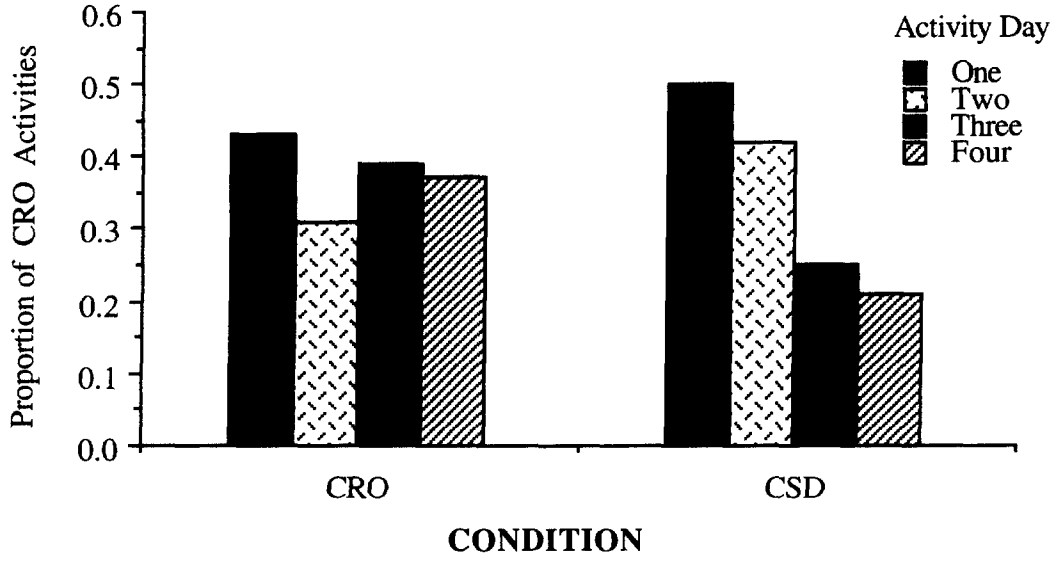

Figure 7. Proportion of all Activities that were *CRO*-Related by Activity Day

Other Effects

Across both groups there was also a significant difference between boys and girls in the types of activities chosen. Boys most frequently chose *CRO*-related activities while girls most frequently chose technology activities not related to *CRO*. Furthermore, girls' activity choices were different from their pretest ratings. Initially, girls rated Non-Technology activities highest, but in the activity periods they were more likely to engage in *CRO*-related and Non-*CRO* Technology activities than in Non-Technology activities.

Anecdotal Evidence of Impact

In addition to the statistical comparisons presented above, observations during the activity periods provide anecdotal evidence that further supports the impact of *CRO* on children's interest in *CRO* -related topics and activities. During the activity periods, children in the *CRO*-group tended to engage in extended exploration and interaction with the *CRO*-related kits and software. Rather than simply building the devices with the LEGO kits, they modified and experimented with the devices they built. In contrast, the *CSD*-group tended to follow the directions for building the devices and did not engage in any further exploration of the devices. Children in the *CRO*-group also created their own *CRO*-related activities during the activity periods, such as using rulers as catapults and playing with a mirror to bounce light off of people. The extended exploration of an object, such as using it in different ways, seeing greater potential for ways to interact with it and repeatedly engaging with it, are all indicators of interest (Renninger, 1992).

Interest in Doing More Activities After Viewing

In each of the interviews we asked children if they engaged in any follow-up activities related to the two preceding episodes of *CRO* or *Where on Earth Is Carmen Sandiego* in other settings, such as at home, the playground, library, etc. Activities were coded as either Content-related or Unrelated. Content-related activities were ones that addressed the

educational aspects of the shows -- science and technology for the *CRO*-group and geography or various arts and science topics for the *CSD*-group. Examples of Content-related activities include building devices, playing with toys or games, reading, visiting museums or science centers, or asking for additional information about the science and technology or the geography and arts and science topics of the episodes. Unrelated activities were ones that did not address the educational aspects of the episodes, such as collecting rocks after the Catapult episode, or taking a hot shower after the Heat & Insulation episode, or playing with a cat after the *CSD* episode on Cats or dressing up as Carmen Sandiego for Halloween.

The *CRO*-group was more likely to engage in Content-related activities than the *CSD*-group after the first two episodes (Mirrors & Periscopes and Catapults versus Music and UFO's), $\chi^2=4.4$, $p < .05$, and after the last two episodes (Traps & Triggers and Buoyancy versus Children's Literature and Low-Tech Challenge), $\chi^2=5.4$, $p < .05$. These included hands-on activities, as well as seeking information. For example, children in the *CRO*-group reported building or playing with objects related to the devices built in the episodes, such as building catapults at home, testing the flotation of objects in the bathtub, and using their mothers' compact mirrors as periscopes. The *CRO*-group also reported asking for or reading about information regarding the devices or technology. For example, after the Timekeeper episode one child asked her mother how her watch worked, and after the Windmill show two other girls re-read their books on windmills.

Interest in Learning about Technology and Non-Technology Topics

In this section we investigate the impact of *CRO* on children's interest in learning about science and technology topics. Four types of data were used to examine this impact: 1) responses to questions from the Learning & Doing Interest measure, 2) interview responses regarding children's interest in finding out more about the show, 3) pretest interest in reading books or pamphlets (as measured by the baseline measure of activity interest), and 4) children's choice of books and pamphlets during the activity period.

Interest in Learning about Topics at Pretest and Posttest

The Learning & Doing Interest measure was a pretest and posttest measure in which half of the items focused on children's interest in learning about three types of topics: 1) *CRO*-related Technology -- technology topics illustrated in the *CRO* episodes (e.g., catapults, windmills, etc.); 2) Non-*CRO* Technology -- topics related to technology that were not presented in the eight *CRO* episodes (e.g., flying machines and levers); and 3) Non-Technology -- topics unrelated to technology (e.g., coins and photography).

Figure 8 shows children's interest in learning about the different types of topics at pretest and posttest. There were no significant changes in interest for any of the topics for the *CRO*- or *CSD*-group (although significant differences were found in children's interest in doing such activities, as noted above). On the pretest children rated learning about both *CRO*-related and Non-*CRO* Technology topics as more interesting than Non-Technology topics ($p < .05$).

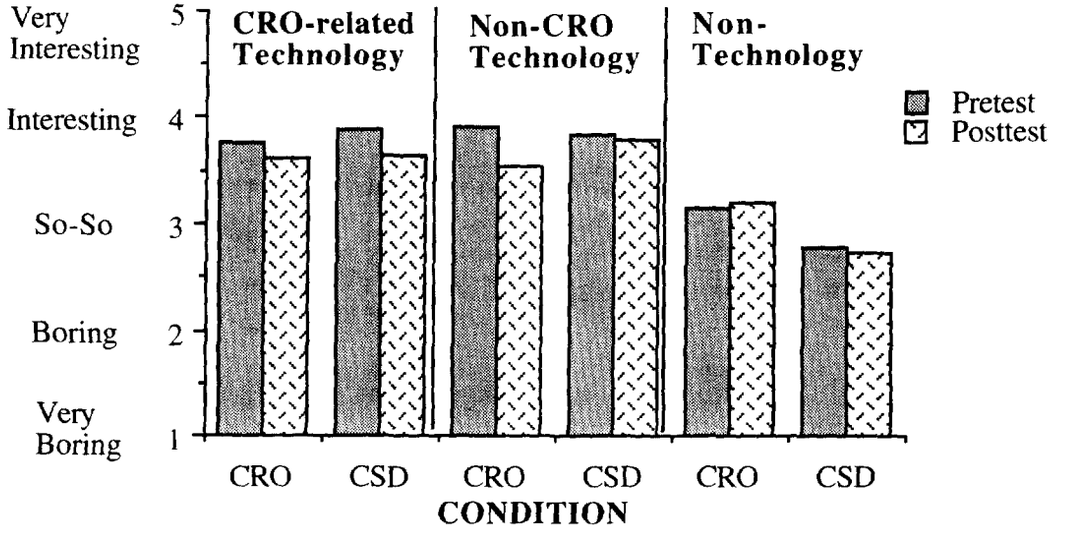

Figure 8. Interest in learning About *CRO*-related, Non-*CRO* Technology & Non-Technology Topics Pretest vs. Posttest

Interest in Learning More about Topics after Viewing

During the weekly interviews, children were asked if they were interested in finding out

more about the topics of the episodes they had viewed and if so, why. Table 7 shows the percent of interview groups in both conditions wanting to find out more about the show topic. For the final episode significantly more children in the *CRO*-group wanted to find out more about the topic in *CRO* than children in the *CSD*-group wanted to find out about the topic in *Carmen Sandiego* (Fisher exact test, $p = .003$).

CRO **Episode Topic (n)**	***CRO***	***CSD***	***CSD*** **Episode Topic (n)**
Mirrors & Periscopes (21)	100%	87%	Music (26)
Catapults (21)	71	69	UFOs (26)
Windmills (25)	76	72	Art (29)
Heat & Insulation (25)	64	59	Cats (29)
Wheels & Belts (24)	75	71	Dinosaurs (25)
Timekeepers (24)	71	64	Chess (25)
Traps & Triggers (25)	68	52	Children's Literature (23)
Buoyancy (25)	92	52	Low-Tech Challenge (23)

Table 7. Percent of Interview Groups Wanting to Find Out More about the Show Topic

In the next analysis we analyzed the reasons why children wanted to learn more. We categorized the children's responses into two categories: Educational or Non-Educational. Educational included any reasons focusing on acquiring information about the educational content of the show: such as, "Because I want to know how to build a catapult" for the CRO-group or "Because I want to know what happened to the dinosaurs" for the CSD-group. Non-Educational included any reasons that did not focus on learning more about the educational content. These statements tended to refer to personal experience (e.g., "Once I jumped off a raft in the lake" or "Because I have a cat") or non-specific appeal of

the episode itself (e.g., "Because I liked it" or "It was funny").

As indicated in Table 8, for the first six episodes, significantly more children in the *CRO*-group gave Content-related reasons for wanting to find out more than children in *CSD*-group, and this effect was marginally significant for the seventh episode. There was no significant difference between the groups for the eighth episode. Thus, although children in the *CSD*-group said they wanted to find out more about show topics, their reasons tended to focus on how the topic related to their existing knowledge or experience, and did not actually refer to an interest in acquiring new information about the subject matter. That is, they talked about owning or having seen or done something related to the topic (e.g., "because I have a cat", "I play chess", or "I saw *Jurassic Park").* In contrast, children in the *CRO*-group wanted to find out more about the devices and how they worked (e.g., "Because I would like to be able to build a catapult" or "Because knowing how to make things float would be interesting").

Episode Topic *CRO/CSD*	***CRO* (n)**	***CSD* (n)**	**Fisher exact p-value**
Mirrors & Periscopes I Music	62% (21)	0% (26)	.0001
Catapults I UFO's	43 (21)	8 (26)	.0065
Windmills I Art	60 (25)	7 (29)	.001
Heat & Insulation I Cats	52 (25)	21 (29)	.023
Wheels & Belts I Dinosaurs & DNA	38 (24)	8 (25)	.018
Timekeepers I Chess	54 (24)	4 (25)	.001
Traps & Triggers I Children's Literature	32 (25)	9 (23)	.076
Buoyancy I Low-Tech Challenge	28 (25)	22 (23)	.74

Table 8. Percent of Interview Groups Wanting to Find Out More About the Educational Content of the Episodes

Baseline Reading Interest Ratings

Prior to treatment, children rated their interest in reading the different books and pamphlets that were later available during the activity periods. For both groups, the books and pamphlets were rated of lower interest than both the toys and the software, $p < .01$. The average ratings for reading material were not significantly different across the three topics: *CRO*-related Technology (mean = 2.7), Non-*CRO* Technology (mean = 2.6), and Non-Technology (mean = 3.0).

Reading Choices during Activity Period

In general, children did not choose to read during the activity period or to take books home overnight. The pamphlets, which were used at two of the sites, were never chosen, and the books accounted for less than 1% of all activities at the third site. Given the very low frequency of use, no analyses were conducted on children's reading behavior.

Summary of CRO's Impact on Children's Interest

In general the results suggest that *CRO* had a positive impact on children's interest in learning about and doing science and technology topics and activities. After viewing *CRO*, the *CRO*-group, in comparison to the *CSD*-group, showed an increased interest in viewing *CRO* and other science shows, a greater interest in finding out more about the content of the episodes, and an increased interest in doing *CRO*-related activities. The largest impact was on average science achievers, who indicated the lowest interest in these types of activities prior to the study. *CRO* had a greater impact on girls in terms of interest in viewing *CRO* and other science shows (*Beakman* and *Bill Nye the Science Guy*), and boys showed a greater increase in interest in participating in activities related to the *CRO* episodes.

The *CRO*-group's behavior was also affected by viewing *CRO*. They were more likely

to engage in the Belts & Wheels activities after viewing this episode than on other activity days and were the only ones to engage in the Timekeeper activity. The *CRO*-group was also more likely than the *CSD*-group to engage in activities outside of the activity period that related to the educational content of the episodes they viewed. On both the first and the last interview, the *CRO*-group reported engaging in more show-related activities than the *CSD*-group, although neither group had been prompted to do so.

IMPACT OF *CRO* ON CHILDREN'S COMPREHENSION OF SCIENCE AND TECHNOLOGY

Children's comprehension was measured via four in-depth interviews, one conducted each week during the study. There were three comprehension measures: 1) Free Recall of each *CRO* or *CSD* episode, 2) a Sorting Task in which children ranked devices from four *CRO* episodes according to the device's ability to solve a particular problem, and 3) an Explanation Task in which children had to explain their rankings of the devices.

Free Recall

At the beginning of each interview, children were asked to recall information from the two episodes they viewed that week. One episode was viewed three days before and the other was viewed one day before the interview. The mean percentage of interview groups recalling any show content was not significantly different between the two viewing conditions -- an average of 62% versus 53%, for *CRO*- and *CSD*-groups, respectively. However, significantly more children in the *CRO*-group recalled information from the show they viewed on the previous day than from the show viewed three days earlier (76% vs. 48%, $p < .05$). In contrast, children in the *CSD*-group were equally likely to recall information from the three-day old and the one-day old shows (Means = 53%); moreover, the level of recall for both *Carmen Sandiego* shows was lower than the level of recall for *CRO* episodes that were viewed on the previous day.

To examine these differences more closely, we compared the type of information that was recalled by children in each group. While many of the *CSD* interview pairs recalled general schema information, that is, information that was consistent with all episodes of *CSD* (e.g., statements such as, "They caught her and she got away," "Carmen Sandiego stole things," or "They tried to catch her but she got away"), children in the *CRO*-group rarely gave general schema statements. Recall in the *CRO*-group reflected children's memory of and attention to specific episodes.

Spontaneous Recall of Educational versus Non-Educational Content

Our next step was to investigate whether children in the two conditions were differentially sensitive to the educational content of the shows. We categorized children's recall statements as consisting of Educationally Relevant Content or Non-Educational Content. For *CRO* Educationally Relevant recall included the devices that were built, the goals of the devices, or how the devices worked. For *CSD,* educationally relevant recall included the geographic locations, or arts and science content. As shown in Table 9, on all but two of the episodes, significantly more interview pairs in the *CRO*-group recalled educationally relevant content than interview pairs in the *CSD*-group. The *CRO*-group tended to recall how the devices worked, how they were made, and the goals of the devices; for example, "there was a tree and when you pulled it back it threw stuff," "they were making a timer," "they used the see-my-selfer [i.e., a mirror] to light up the cave," "they needed lots of wheels and belts for the machine for Esmerelda," and "they used balloons and sticks to lift the statue out of the water." Few children in the *CSD*-group recalled geographic (e.g. "they went to the pyramids") or other educational content (e.g., "Beethoven was a famous musician").

Episode Topic	*CRO* (n)	*CSD* (n)	p-value
Mirrors & Periscopes/ Music	48% (21)	0% (26)	$p < .0001$
Catapults/ UFOís	71 (21)	8 (26)	$p < .0001$
Windmills/ Art	24 (25)	12 (29)	$p > .1$
Heat & Insulation/ Cats	48 (25)	7 (29)	$p < .0001$
Wheels & Belts/ Dinosaurs & DNA	33 (24)	0 (25)	$p < .0001$
Timekeepers/ Chess	54 (24)	4 (25)	$p < .0001$
Traps & Triggers/ Childrenís Literature	25 (25)	9 (23)	$p > .1$
Buoyancy/ Low-Tech Challenge	48 (25)	4 (23)	$p < .0001$

Table 9. Percent of Children Recalling Educationally Relevant Content from each Episode

Table 10 shows the percent of interview groups recalling non-educational content for both conditions. During the first two weeks significantly more children in the *CSD*-group than the *CRO*-group recalled non-educational content, but this was only for shows viewed three days earlier, and which, as mentioned previously, was due to general schema recall. Later in the study there were no significant differences in recall between the groups except for the final show, where more children in the *CRO*-group recalled non-educational content than the *CSD*-group. For the *CSD*-group typical recall consisted of events or characters in the specific episodes: for example, "It was about a white leopard" (from the Cat episode), or "She wanted the biggest chess game" (from the Chess episode). The *CRO*-group made similar statements, especially about characters: for example, "it had these large, grumpy mammoths, Earl and Mojo" (from the Wheels & Belts episode), and "it was about an elephant who was dirty" (from the Heat & Insulation episode).

Episode Topic	*CRO* (n)	*CSD* (n)	p-value
Mirrors & Periscopes/ Music	42% (21)	75% (26)	$p < .05$
Catapults/ UFOís	71 (21)	63 (26)	$p > .25$
Windmills/ Art	32 (25)	62 (29)	$p < .05$
Heat & Insulation/ Cats	64 (25)	66 (29)	$p > .5$
Wheels & Belts/ Dinosaurs & DNA	29 (24)	40 (25)	$p > .5$
Timekeepers/ Chess	46 (24)	52 (25)	$p > .5$
Traps & Triggers/ Childrenís Literature	28 (25)	35 (23)	$p > .5$.
Buoyancy/ Low-Tech Challenge	60 (25)	30 (23)	$p < .05$

Table 10. Percent of Children Recalling Non-Educational Content from each Episode

Taken together, the recall findings show that the *CRO*-group were better at recalling the content of the episodes than the *CSD*-group: they were generally as good as the *CSD*-group at recalling non-educational specific content and were significantly more likely than the *CSD*-group to mention educational content spontaneously in their free recall.

Comprehension of CRO Science and Technology Topics

As noted above, children were asked to rank the effectiveness of devices shown in *CRO* and to explain their rankings. Children's ranking of the devices was scored using the coding scheme in Appendix F. We categorized children's ranking into three groups: 1) *CRO* -consistent: the ranking matched the evolution of the devices in the episode; 2) Alternative-correct: the ranking was different from the episode but could also be correct; and 3) Incorrect: at least one device picture was ranked incorrectly. Children were given the maximum number of points for *CRO*-consistent and Alternative-correct rankings and received fewer than the maximum number of points for Incorrect rankings. We conducted two types of analyses: a

quantitative analysis based on the number of points received and a qualitative analysis based on the three different sorting strategies used. If children in the *CRO*-group rank the devices consistent with the episodes and the *CSD*-group rank them differently, it suggests that the *CRO*-group's understanding was affected by their exposure to *CRO*.

Children's explanations were coded according to the conceptual frameworks that they used to explain their ranking of the devices. For each device, children's explanations were categorized into one of three conceptual categories: focus on the surface features, misconceptions about the mechanics, and causal or mechanistic explanations. (The coding scheme is given in Appendix F.)

We also computed an overall comprehension score for each interview. This score was based on the combined sorting task score and explanation scores. In the next section we present the comprehension results from each interview by first presenting the overall comprehension results followed by the sorting task and explanation task results.

Catapult Interview

Overall Comprehension

Figure 9 shows the total comprehension score for the *CRO*- versus *CSD*-groups. The children in the *CRO*-group demonstrated a better overall understanding of the concepts and devices than the *CSD*-group (Means = 17.2 versus 14.9, Max. = 22), $p < .005$. The average and high science achievers in the *CRO*-group performed significantly better than the average and high science achievers in the *CSD*-group, p's $< .005$. This effect held for both boys (in the average and high achievement groups) and girls (in the high science achievement group).

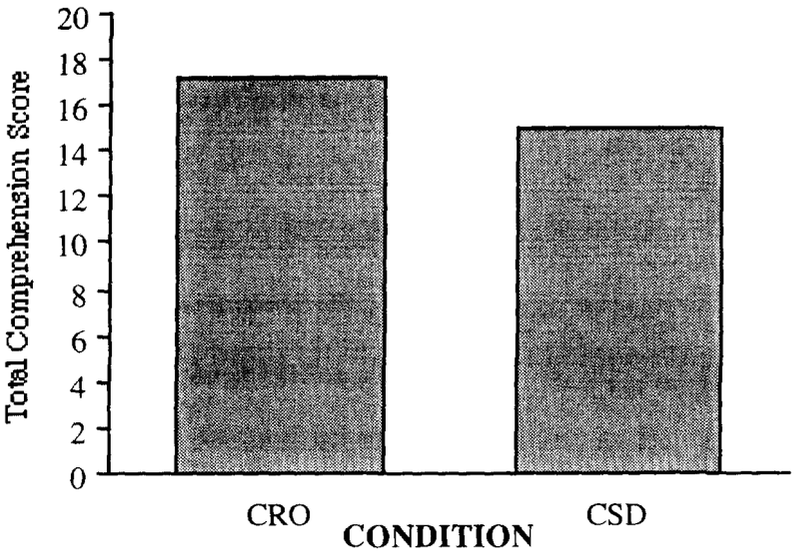

Figure 9. Catapult Interview: Total Comprehension Score by Condition

Ranking the Throwing Devices

Children received zero to three points based on their ranking of the four devices that were illustrated in the *CRO* episode. The correct ordering, from best to worst was: 1 and/or 2) Trebuchet (or Bent Tree); 3) Jumping on Board; and 4) Throwing the Rock (see Appendix D1 for these pictures). Children received three points for getting all four items in the correct position, two points if two items were in the correct position, one point if only one item was in the correct position and zero points if no items were in the correct position.

Eighty-three percent of the *CRO*-group versus 48% of the *CSD*-group ranked the devices correctly, $p < .01$ (Means = 2.79 versus 2.29, for *CRO* and *CSD*, respectively). When the *CRO*-group sorted the devices correctly they tended to use the order that was consistent with the episode -- 71% versus 12% who used an alternative but correct ordering. In contrast, when the *CSD*-group was correct, there was no strong bias to sort either way -- 29% used a *CRO*-consistent and 19% used an Alternative-correct ranking. The frequency of children who sorted the devices in a way that were consistent with the show compared with those who chose an alternative (but valid) ranking was significantly

different between the two groups, χ^2=14.5, $p < .001$. Thus, children in the *CRO*-group more often ranked the devices correctly, and more often ranked them consistently with the show, suggesting that *CRO* did impact on children's naive beliefs about these devices.

Explaining the Throwing Devices

After children ranked the four devices, they were asked to explain why each device was better or worse for throwing a rock really far. Overall the *CRO*-group produced more sophisticated explanations for the devices than the *CSD*-group (Means = 7.4 versus 6.5, Max. = 13), $p < .06$ (See Figure 10). When explaining how the lever, tree device, and the trebuchet worked, 20% the *CRO*-group (versus 8% of the *CSD*-group) explained the mechanism underlying the devices: for example, "it [trebuchet] will throw it far because the rock in the machine is heavier than the rock they are trying to throw," and "the tree has more power because you can bend it back more." In general, children in the *CSD*-group were more likely to focus on surface features or harbor misconceptions (e.g., "the caveman might miss the board and fall in the hole") than the *CRO*-group, 40% vs. 30% respectively.

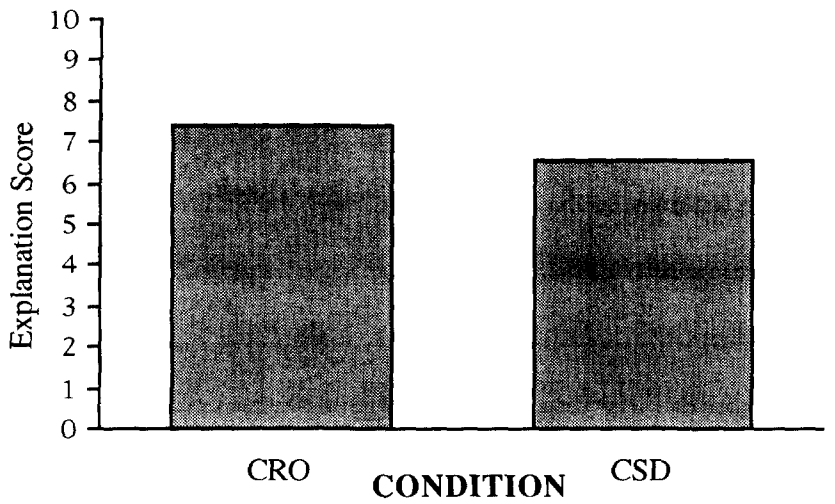

Figure 10. Catapult Interview: Explanation Score by Condition

Explaining How to Make the Devices Better

Children were asked how they could make the tree and the trebuchet throw the rock even further. There were no significant differences between the groups (Means = 4.5 versus 4.4, Max. = 6). In both groups approximately one-half of the children gave explanations that referred to storage of energy; for example, "You could get a heavier rock to put in the machine," or "You can pull the tree down farther."

Ranking and Explaining the Ratchet Device

In a second task, children were asked to rank and explain two systems -- one with a ratchet system and the other without. Children were shown two pictures of the characters pulling on a rope that was tied to a tree; in one picture the rope had no knots and in the other the rope had knots that they would pull through a notch in a tree trunk which would catch and hold the rope between pulls. The *CRO*-group was more likely to pick the rope with the knots as better than *CSD*-group, $p < .001$. Furthermore, as shown in Figure 11, the *CRO*-group gave more sophisticated explanations of the advantages of the knot system (Means = 1.7 versus 1.0, Max. = 2), $p < .001$; typically, they focused on the way the knots functioned as a ratchet, for example, "Because you can rest and it will hold it," and "The knots get stuck and hold the tree back." Eighty percent of the *CRO*-group's explanations centered on how the knots functioned as a ratchet, compared to only 21% of the *CSD*-group; instead, 61% of the *CSD*-group's explanations focused on surface features, such as "The knots make it easier to hold on" or "The knots will get stuck and it will be harder to pull."

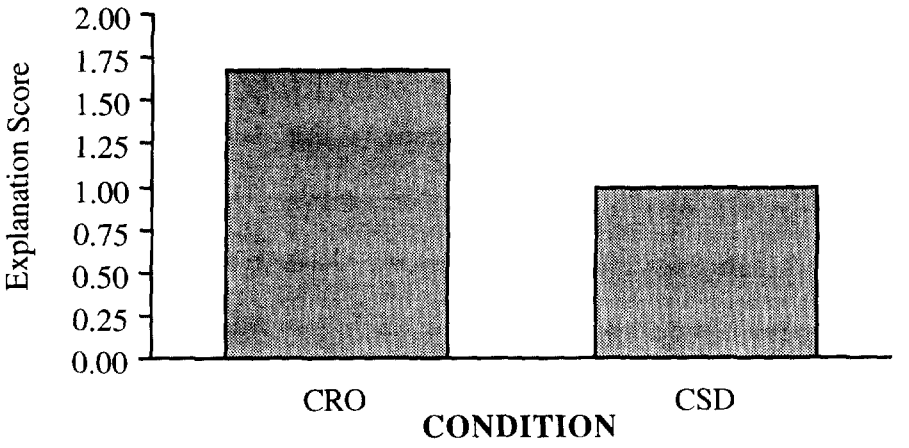

Figure 11. Catapult Interview: Explanation Scores for Ratchet by Condition

Heat & Insulation Interview

Overall Comprehension

Figure 12 shows the overall comprehension scores for the Heat & Insulation Interview. Children in the *CRO*-group demonstrated a marginally better understanding of heat and insulation than the *CSD*-group (Means = 12.6 versus 11.3, Max. = 20), $p < .07$. This effect was due to *CRO* girls (particularly those who were high science achievers) performing better than their *CSD* counterparts, $p < .05$.

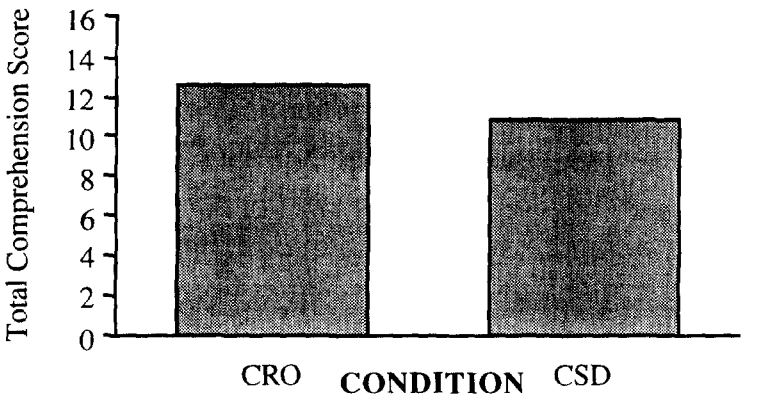

Figure 12. Heat & Insulation Interview: Total Comprehension Score by Condition

Ranking the Devices for Heat Transfer

In the first sorting task the devices emphasized transfer of heat. Children were shown two pictures: the first showed a pipe system running down the mountain over hot rocks and the second showed the pipe system going around the hot rocks. Children received one point if they chose the pipes over the hot rocks as the best solution for producing a hot shower, otherwise, they received zero points.

All the children in the *CRO*-group correctly ordered the devices compared to only 78% of the *CSD*-group (Means = .82 versus .67), $p < .05$. Only the girls in the *CSD*-group made errors in the ordering.

Explaining the Devices

Figure 13 shows the explanation scores for the around the hot rocks and over the hot rocks pictures. There were no significant differences in the quality of explanations that children gave to explain the two systems (Means = 5.0 versus 4.4, for *CRO* and *CSD*, respectively, Max. = 10), $p > .1$. Seventy-five percent of the *CRO*-group focused on some mechanism underlying the transfer of heat (e.g., "without the hot rocks the water will get cold as it comes down the mountain") versus 55% of the *CSD*-group. Although not significant, the *CSD* -group was slightly more likely to harbor misconceptions or focus on surface features (e.g., when it goes around the rocks "it comes down faster") to explain the devices than the *CRO* -group -- 40% versus 28%, respectively.

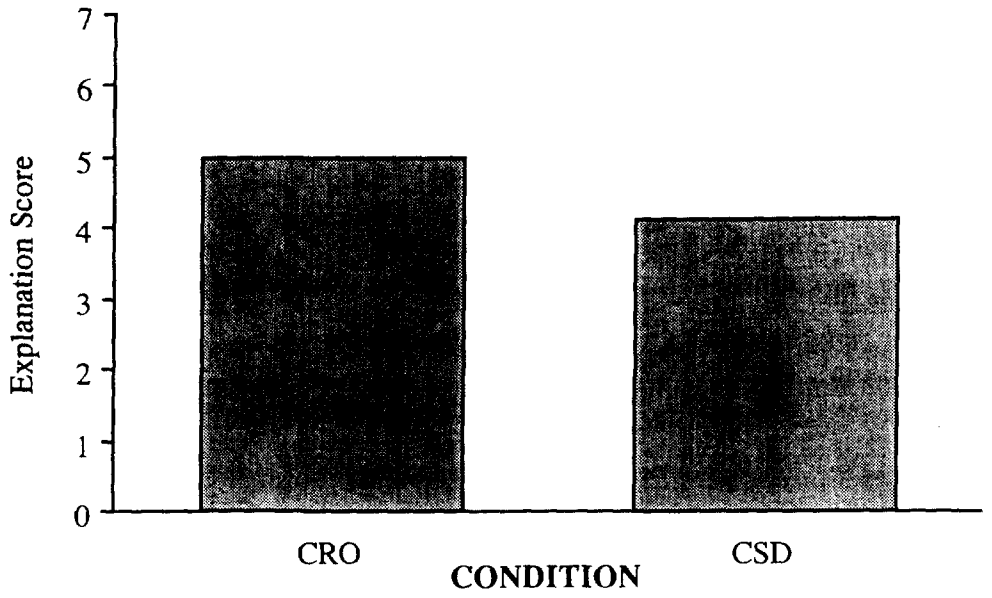

Figure 13. Heat & Insulation Interview: Explanation Scores for Over vs. Around Hot Rocks by Condition

Ranking the Insulation Devices

Children were also given a second sorting task that focused on the mechanism of insulation. The second sorting task had pictures of three devices: 1) A shower with no tank; 2) A shower with an uncovered tank; and 3) A shower with an insulated and covered tank. Children received one point if they put the insulated tank in the first position, and zero points if it was placed in any other position (see Appendix D.2 for these pictures).

Children in the *CRO*-group were more likely than the *CSD*-group to regard the insulated tank as the best device (Means = 1.8 versus 1.6), $p < .05$. Seventy-seven percent of the *CRO*-group chose the insulated tank as the best device compared to 66% of the *CSD*-group. Furthermore, the *CRO*-group was more likely to order the devices consistent with the show (72%) than the *CSD*-group (44%), $\chi^2 = 6.4$, $p < .05$.