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Anchoring Classroom Instruction to a Realistic Context: The Jasper Project as an Example

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This article reviews Vanderbilt University's Jasper Project, research and development of materials in detail, in order to explore the possibility and problems of anchoring classroom instruction to a realistic context. The Jasper Project was designed to support anchoring instruction of math problem solving based on situated learning. Six adventure stories, which play the central role of the Jasper materials, and seven design principles are first introduced, along with data from their evaluation study. Among the seven material design principles are: video-based format, narrative with realistic problems, generative format, embedded data design, problem complexity, pairs of related adventures, and links across the curriculum. Three possible ways (Direct instruction with basic first and immediate feedback, structured problem solving, and guided generation model) of using the Jasper series are then examined including their underlying views of instruction and new roles of teachers under the Guided Generation Model, the advocated model for Jasper instruction. Critiques of the Jasper materials from the instructional design viewpoint and that of situated learning are finally summarized in respect to the 'reality' of the context of classroom instruction.

Keywords:
Instructional development, math education, videodisc, Jasper Project, instructional context

Introduction

The theme of producing more practical and realistic classroom instruction has long been dealt with in the domain of educational media research. Among recent opinions insisting on the constructivist approach or situated learning, instructional design methods for the purpose of putting classroom instruction in more realistic context have been explored. In such research efforts, the role of visual materials is especially influential. This article reviews in detail the Jasper Project, which has been drawing the attention of educational technology researchers in the U.S., in order to explore the possibility and problems of anchoring classroom instruction to a realistic context.

1. Jasper Project: Anchored instruction

The Jasper Project is the research and development of materials supporting anchored instruction based on situated learning by the Learning Technology Center (LTC) of Vanderbilt University in the state of Tennessee, U.S.A (CTGV, 1991; 1992a; 1994). The project is aimed at nurturing the skills of discovering and solving math problems, targeting 5th of 6th graders (some mention 5th - 8th graders). The materials consist of video discs as the main material to present challenging realistic instructional context, a multimedia database, problem solving tools (presented by HyperCard), and additional printed materials. Development of the material was funded by the National Science Foundation (NSF) and

others, and a material package of the three sets of two video discs is on sale by the Optical Data Corporation.

The Jasper Project is highly acclaimed. The visual materials developed in the project won a prize in terms of its video production at the New York Film Festival. Furthermore, the project won the most excellent paper award by the Division of Instructional Development (DID) of the Association for Educational Communications and Technology in terms of its instructional design. The project is also taken up by and contributing to the discussion of theoretical foundations for educational technology and educational media research: discussions on constructivism approaches and situated learning (Educational Technology, Special issues in May 1991 and March 1993; and Seels & Richey, 1994); and discussions on the influence on media learning (Kozma, 1994). It is also often taken up as an example of instructional materials.

The Jasper Project was developed by a group of approximately 70 researchers in LTC led by J. D. Bransford, who is famous as a cognitive psychologist. The research group, as of 1994, has been dealing with a project covering a wide range of educational domains including mathematics, science, social science, and literacy. The group's research results are published under the name of Cognition and Technology Group at Vanderbilt (CTGV) as the author. The number of its papers related to the Jasper Project has exceeded 25 for the five years from 1990 to 1994 (CTGV, 1994).

The visual materials playing the core role of the Jasper materials, other supportive materials, outcomes of the Jasper Project, design principles of the material, and types of instruction using the material will be examined in order below.

2 The Jasper Adventure Story and Materials

Jasper is the name of the hero. The adventure story consists of 6 episodes, each of which is 14 minutes to 18 minutes long. Episodes include mathematical problem presenting scenes in an everyday context. The adventure story ends with shooting problems that one of the characters faces to the child audience. The children who viewed the story face the problem in place of the characters. Two problems are prepared for each of three problem types; trip planning using time and distance, project planning using statistical data, and route finding using geometry.

In the first episode of the Jasper Adventure, "Journey to Cedar Creek," the hero Jasper Woodbury visits Cedar Creek going upstream in order to see a used boat advertised in a newspaper. At the end of the episode, there is a task to judge if Jasper can drive the boat he has bought back by sunset without running out of fuel. The child audience have to make their judgment in place of Jasper by sorting out complicated situations one by one. To this end, they have to find hints embedded in the video discs they have viewed before the problem was presented (e.g., working out the distance using the map, knowing the time of sunset by listening to the radio). The children who viewed the video with absorbing interest have to think what kind of information they need to solve the problem presented at the end. They recall the contents of the video, or watch the necessary part of the video again, in order to sort out the data (for details, see CTGV, 1991; p.37).

Table 1 indicates a list of scenes from the "Journey to Cedar Creek" and information embedded in the video disc. During approximately 15 minutes from the beginning to the end

Table 1 List of Embedded Information in the First Episode of the Adventure of Jasper, "Journey to Cedar Creek"

No.	time elapsed	Scene	Presentation method*1	Numerical information*2	Contents
1	14"	Advertisement of a boat similar to the one Jasper wanted was placed in the classifieds of the newspaper	Narration	5-Iron	Number of the golf club Jasper is swinging
2	43"		Advertisement and narration	'56Chris Craft	Name of the boat
3	1' 22"		Map	132.6	Location of Jasper's dock (Mile marker)
4	1' 27"	Checks the seller's place on the map	Same as above	156.6	Location of Cedar Creek (Mile marker)
5	1' 33"	Starts immediately in a boat	Weather forecast on the radio	14 ft	Size of the Sweetie π (Jasper's boat)
6	1' 34"		Same as above	2 hr	Time taken to reach Cedar Creek
7	1' 44"	Timely enough, weather forecast is being announced on the radio placed on the boat	Same as above	91 degrees	Temperature on the Fahrenheit scale
8	1' 49"		Same as above	33 degrees	Temperature on the Celsius scale
9	1' 51"		Same as above	7:52 p.m.	Sunset time
10	1' 55"		Same as above	5:13 a.m.	Sunrise time tomorrow
11	1' 58"		Same as above	85%	Humidity
12	2' 01"		Same as above	50%	Chance of rain
13	2' 03"		Same as above	4 mph	Wind speed
14	2' 05"		Same as above	West	Wind direction
15	2' 43"		Jasper's words and actions	1 pt	Gas required for the Sweetie π
16	3' 03"	Refuels at the gas station on the way and pays with a 20 dollar bill Jasper had	Sign on the gas pump	$1.29.9	Gas price at Larry's shop
17	3' 03"		Same as above	$.04	Discount rate per gallon for cash payment
18	3' 21"		Sign and Larry's words	$6.50	Total price
19	3' 21"		Same as above	5	Total amount of gas in gallons Jasper bought
20	3' 21"		Larry's words	5 gal	Capacity of gas tank of the Sweetie π
21	3' 34"		Jasper and Larry's words	$20.00	Bill used for the payment (all the cash Jasper has)
22	4' 27"	Passes by a large tow of barges	Narration	2football fields	Size of the tow of barges
23	4' 29"		Same as above	9	Number of barges tied together
24	4' 31"		Same as above	Three wide and three long	Way of tying the barges together
25	4' 35"		Same as above	35 ft wide; 200 ft long	Size of each barge
26	6' 14"	Problem with the propeller	Sign on Willie's shop	8 a.m.-5 p.m.	Willie's shop hours
27	6' 14"	Rows into the repair shop, and has the boat fixed	Same as above	140.3	Location of Willie's shop (Mile marker)
28	6' 18"		Same as above	$1.102	Gas price at Willie's shop
29	7' 03"		Narration	$8.25	Repair fee
30	8' 10"	Arrives at the destination, and looks for the seller	Sign for Sal's Dock	156.6	Location of Cedar Creek (Mile marker)
31	8' 20"		Narration	1 tank	Time taken from Willie's shop
32	8' 24"	Meets the seller, who is a female, and starts negotiation	Same as above	80 min	Time taken from Willie's shop
33	9' 47"		Painted sign on a fuel tank	12 in. × 12 in. × 20 in.	Size of the temporary fuel tank
34	9' 50"	Sal tells Jasper about the boat	Sal's words	5 gal/hr	Amount of fuel consumed by Sal's boat per hour
35	9' 59"		Same as above	Defective running lights	Sal's warning about the boat
36	10' 17"	Both agree that the boat needs a library	Same as above	30 gal	Capacity of the water tank
37	10' 56"		Image	76 in.	Size of the berth in the boat
38	10' 59"		Narration	6 ft 2 in.	Jasper's height
39	12' 11"	Go for a test ride	Image	156	First mile marker used for the speed test
40	12' 37"		Image	155	Second mile marker used for the speed test
41	12' 42"	Decides to buy the boat	Narration and image	7.5 min	Time taken to go between the two mile markers (1 mile)
42	13' 12"	Jasper pays Sal with his last check, and wonders if he can return home by sunset	Narration	One-half full	Amount of fuel left in the tank of Sal's boat
43	13' 28"		Sal's words	6 gal	Amount of fuel added
44	14' 30"		Narration	2:35 p.m.	Current time
	Note:	*1 Among the presentation methods, those indicated in italics are only auditory presentations.			
		*2 Among the numerical information, those indicated in boldface in the outline boxes are to be used for solving problems.			

Table 2 Sample of Processes to Solve Problems in the First Episode of the Adventure of Jasper, "Journey to Cedar Creek"

No. of formula	Items to be found	Formula	Data sources (number in brackets (< >) indicates no. of embedded information in Table 1)
	Problem: The running lights do not work. Can Jasper return home by sunset?		
	Subordinate problem 1: Does he have enough time?		
1	Total travel distance	156.6 mi - 132.6 mi = 24.0 mi	156.6 mi is found in <4> and <30>; 132.6 mi is found in <3>
2	Average speed of the boat	60 min/hr × 7.5 min/mi = 8mph	7.5 min/mi is found in <41>
3	Total time taken	24 mi ÷ 8 mph = 3hr	24 mi is the answer for Formula 1; 8 mph is the answer for Formula 2
4	Time left until sunset	7:52 - 2:35 = 5:17	7:52 is found in <9>; 2:35 is found in <44>
	→→→→→→→→→ **Conclusion: He has enough time (with 2 hours and 17 minutes to spare).**		
	Subordinate problem 2: Is there enough gas?		
5	Amount of gas required	3 hr × 5 gal/hr = 15 gal	3 hrs is the answer for Formula 3; 5 gal/hr is found in <34>
6	Amount of gas left	6 gal × 2 = 12 gal	6 gal is found in <42> and <43>
7	Amount of gas lacking	15 gal - 12 gal = 3 gal	15 gal is the answer for Formula 5; 12 gal is the answer for Formula 6
	→→→→→→→→→ **Conclusion: 3 gallons of gas will be lacking. It is necessary to refuel on the way.**		
	Subordinate problem 3: Can the boat reach Willie's shop without running short of gas?		
8	Distance to Willie's shop	156.6 mi - 140.3 mi = 16.3 mi 16 mi	156.6 mi is found in <4> and <30>; 140.3 mi is found in <27>
9	Time needed to reach Willie's shop	16 mi ÷ 8 mph = 2 hr	16 mi is the answer for Formula 8; 8 mph is the answer for Formula 2
10	Amount of gas needed to reach Willie's shop	2 hr × 5 gal/hr = 10 gal	2 hrs is the answer for Formula 9; 6 gal /hr is found in <34>
11	Amount of gas left when the boat arrived at Willie's shop	12 gal - 10 gal = 2 gal	12 gal is the answer for Formula 6; 10 gal is the answer for Formula 10
	→→→→→→→→→ **Conclusion: The boat can reach Willie's shop without running short of gas (with 2 gallons to spare).**		
	Subordinate problem 4: Can Jasper buy the required amount of gas at Willie's shop?		
12	Amount paid at Larry's shop	$6.50 - $.20 = $6.30	$6.50 is found in <18>; $.20 is worked out by <17> * the number of gallons of gas bought
13	Amount of cash Jasper has (after buying gas)	$13.70 - $8.25 = $5.45	$20.00 is found in <21>; $6.30 is the answer for Formula 12
14	Amount of cash Jasper has (after paying repair fee)	$20.00 - $6.30 = $13.70	$13.70 is the answer for Formula 13; $8.25 is found in <29>
15	Amount of gas Jasper can buy at Willie's shop	$5.45 ÷ $1.11/gal = 5 gal…-10	$5.45 is the answer for Formula 14; $1.11 is the round figure of <28>
16	Comparison of the amount of gas needed to refuel and amount of gas Jasper can buy	5 gal > 3 gal	5 gal is the answer for Formula 15; 3 gal is the answer for Formula 7
	→→→→→→→→→ **Conclusion: Jasper can buy the required amount of gas with the cash he has.**		
	Subordinate problem (additional): Can Jasper afford to eat ice cream with Sal?		
17	Cash	$5.45 - $3.33 = $2.12	
18	Time (until sunset)	5:17 - 3:00 = 2:17	
19	Time (until closure of Willie's shop)	2:35 + 2 hrs = 4:35	
	→→→→→→→→→	**Conclusion: Even if Jasper starts immediately, he will arrive at Willie's shop only 25 minutes before the shop closes.**	
		Judgment: If Jasper refuels the boat at Willie's shop, he can return home by sunset.	
		However, the shop will close soon, so he should eat ice cream with Sal another time.	

of the episode, 44 numerical data is embedded in subtle ways including narration and weather forecasts on the radio and visual presentations such as maps, advertising displays, signs, actual items, and so on. Among the embedded 44 numbers, only 17 are effective for problem solving and the rest is unuseful (effective rate: 39%). The children who face the difficult problem at the end of story will think how and what information should be used to solve the problem by themselves, and will look for a solution.

Table 2 indicates the model solving process of the problem presented by the adventure story. Jasper bought a boat with defective lights. In order to obtain the answer to the question "Is he able to return home by sunset?," children have to find the subordinate problem of working out the time left and the amount of gas left. In order to do this, they have to find the embedded information required, set up the formula, and calculate. During this process, they find out that the gas will run short. Then, they have the next subordinate problems, and have to judge if the boat can reach a refueling point on the way and if they have enough money to buy gas. Solving four subordinate problems, and setting up a total of 16 formulas for solving those subordinate problems, the children conclude that Jasper can return home by sunset.

2. Other materials to support the adventure story

Each video disc of the Adventure of Jasper on sale has one episode. On the front side of the adventure story disc, "what-if" analogs are printed in order to introduce changes to the story. Table 3 indicates the "what-if" analogs prepared for the first episode "Journey to Cedar Creek." These analogs are to be used as practice problems after the problem of the adventure story is solved.

Table 3 "What-if" Analogs of the "Journey to Cedar Creek"

Price of gas: If the gas price changes, can Jasper reach home? Price per gallon: $1.20, $1.30, $1.60, $1.75, $1.85
Speed of river flow: If the speed of the river flow changes, can Jasper reach home? Speed per hour: 0 mile, 2 miles, 3 miles and 7 miles
Capacity of gas tank: How much capacity does the tank have if the length, width, or height of the tank changes? Length (inches): 20*12*12, 6*12*20, 24*24*40, 24*24*20, 24*12*20
Change of two variables: If the capacity of the gas tank and the amount of gas consumption change, can Jasper reach home? If not, can he reach the Willie's shop? 15 gallon tank & 6 gallons per hour, 15 gal & 4 gal/hr, 10 gal & 6 gal/hr, 10 gal & 4 gal/hr, 11 gal & 5 gal/hr
Change of three variables: What if the gas price changes as well as the capacity and consumption? $.99 & 20 gal & 6gal/hr, $.99 & 16 gal & 6 gal/hr, $1.35 & 16gal & 7 gal/hr, $.80 & 14 gal & 7 gal/hr
Trip plan: Let's plan a trip using a river barge. What should we take into consideration in planning? How many days does the trip take? How much fuel is required?

On the reverse side of the video disc, an example of the problem solving process of the adventure story is presented by the hero in order to encourage children to compare it with their own solutions. Furthermore, an introduction of the whole Jasper series, general hints for instruction, and points to note in the instructions according to the contents and steps of problem solving are provided to classroom teachers who use the Jasper materials.

The video discs are accompanied by a teachers' manual with HyperCard stacks to control the video disc. The teachers' manual includes a detailed explanation of the adventure story, model curriculum, explanation of how to use similar practice questions, ideas for linking other subjects, a list of math skills required, and information for children. The outline of the adventure story provides barcodes in order to retrieve a specific scene easily. They are prepared in case users cannot control the video discs by Macintosh HyperCard stack.

Other than the above, it is reported that the following multimedia database and computer materials to support the problem solving process called "Jasper Project Assistant (JPA)" had been developed as supplementary materials prepared by the Jasper Project. However, they were not attached to the video disc materials on sale.

According to some reports, the multimedia database provides opportunities to combine mathematic problem-solving skills with an historic, geographic or scientific context, especially focusing on liaison with other subject matters (Database Publisher; CTGV, 1991, p.38). For example, historic information about a boat operated manually in Mark Twain's days at maybe this speed can be added to the story, in order to provide opportunities for solving the problem under different conditions. When the conditions differ, a need to solve the problem taking various other factors into consideration is generated (e.g., As Jasper apparently cannot reach home by sunset, he should secure necessary food and water needed on the way instead of fuel, etc.). Accordingly, the structure of the process of solving the problem also changes. The material includes functions to prepare many mini adventures to practice the problem solving methods used in the adventure, to let children practice basic calculation skills, and to enable children to add information they acquire independently to the database are also prepared (Adventure Maker; CTGV, 1992a, p.72). Furthermore, it is reported that a computer operated multimedia database, simulation material operated simultaneously with the adventure story, as well as printed material are being prepared (CTGV, 1993a, p.57-58).

JPA is a HyperCard stack prepared to support children who learn with Jasper materials. It has functions of video disc control, calculation, memory of actual information, and others. It provides scaffolding for problem-solving beginners by structuring a problem solving process. Furthermore, there are various kinds of HyperCard: question cards to promote the generation of questions; planning cards for sorting out what kind of information is required to answer the question; information cards for making notes of information collected from the video disc; calculation cards with portable calculator; and observation cards for looking over map information. Each HyperCard is reported to be linked to other cards based on the problem solving process. For example, children cannot go on to the next stage before generating a question on the question card first (Young, 1993, p.51, 52).

3. Outcomes of the Jasper Project

The Jasper materials were used in 75 or more schools in the U.S. in FY 1990-1991. Among those schools, 16 state elementary schools in 9 states in the Southeast part of the U.S. were targeted by the field test. The results of the field test conducted on 739 pupils in the 5th and

6th grades reported that not only children but also teachers and the PTA highly appreciated the materials (CTGV, 1992b). This field test was operated by two teachers who received two-week training beforehand and one assistant dispatched by the business corporation. The control group subjects in ten classes that did not use the material and the experimental group subjects in 7 classes learned three or four episodes of the Jasper materials in class taking at least one week's class hours for each episode. The paper test was conducted before and after the learning, and the scores were assessed. Four tests were developed in addition to the standard math test. With those four tests, whether or not the subjects achieved the following three points that the Jasper Project aims for was checked: (1) the ability to generate problems on their own, not to solve ones made by others, (2) appreciate the usefulness of math, and (3) motivation to challenge complicated problems. The evaluation results are as follows (CTGV, 1992b).

The results of evaluation before and after show that the experimental group got higher scores in word problems and planning tests, and the acquisition of the basic math concepts was not impaired. In the basic math concept test changes in the degree of understanding of the concept of area/volume/decimal point/fractions required to solve problems in the Jasper materials was looked for. It was anticipated that scores of the basic math concept test may be lower than the control group, because there are items that are required in the Jasper materials but are not directly taught in it, and the number of class hours to be used to teach the basic concept may decrease due to the use of the Jasper materials. However, there was no significant difference between the control group and the experimental group.

The word problem test, which is often used for measuring problem solving ability, was adopted by the Jasper materials to evaluate skills corresponding to transfer. Three types of problems, from problems solved in one step to complicated ones solved in many steps, were prepared. It was predicted that the more complicated a problem is, the superior the Jasper material group is. In all of the three types of problems, scores of the Jasper material group were significantly higher than those of the control group.

Planning problems is defined as generative problems concerning complicated planning that consists of many stages. It includes the problem of designing the whole problem solving process, the problem of explaining the reason why a presented formula is required for this plan (degree of understanding the subordinate goals), and calculation problems. In planning the whole process (comparing the adjusted rates of the average right answers in pretest, the Jasper material group amounted to 40%, while the control group amounted to 25%) and in the degree of understanding of subordinate goals (54% in the Jasper group; 46% in the control group), significant differences were found.

In terms of attitude, the results for the Jasper group were also good. In the survey of the degree of consent to 35 items concerning attitude toward math and causal attribution of math scores, stability was predicted in the items of causal attribution and ability of math. As expected, no significant change was found. In the four domains of anxiety/confidence in arithmetic, recognition of usefulness of arithmetic, interests in arithmetic, and challenging spirit to arithmetic, however, significant differences were found in pre/post changes between the experimental group and the control group (CTGV, 1992b).

The Jasper materials gained a good reputation from user teachers and parents. It was frequently mentioned in children's everyday living and in other subjects. A children's field project developed from the Jasper materials was frequently conducted. The intention of the

developers was that the Jasper materials would be merely an initiating agent, with the ultimate goal being that the acquired problem solving skills are used in the later activities. The intention has been realized. Furthermore, a system to mutually present the project conducted in various places through computer communication is reported to be under examination (CTGV, 1993a).

In the large scale field test, frequent implementation of assessment (paper tests) fell into disfavor with children. So, in order to improve the assessment method, an e-conference called Challenge Series which combines TV broadcasting and PC communication was planned. In the e-conference, a game-show type conference was adopted in order to examine whether the problem solving skills acquired in the Jasper materials can be applied to the newly presented problem scenes. In the game-show type conference, children watch three live characters challenging the similar problems to the Jasper materials and cast their votes for the one they think is the true expert. For children, the test itself seemed to be new material. They commented that they did not have any unpleasant feelings when they were tested by repeating the already learnt skills again like a paper test. This method uses the assessment, which adopts game-show and e-conference, and its results for adjusting of the next instruction plan. The possibility to generalize the method and use it not only in the Jasper project but also in materials of problem solving projects (e.g., the Voyage of the Mimi, Acid Rain Kids Web) was also indicated.

4. Seven material design principles which led to success

It is reported that seven design principles were adopted for the designing of the Jasper materials (CTGV, 1992a; 1993b). All these principles, which are rules of learning context formation, are important designing guidelines which led the Jasper Project to success. The design principle and the intended effects are described below.

(1) Video-based format

Videos are set as the core material in order to present information in interesting forms elaborating characters, scenes, and the story. Video presentation enables complicated and difficult information to be expressed on a screen. As individual children obtain different information from the screen, video presentation provides opportunities for a group of many children to contribute to the problem solution through collaborative work. As the video-based material does not have to present numerical data in text format, it is able to let children concentrate on understanding not numerical data but content of the problem story in the first video watching. After they get the picture of the problem structure, they can view the video again to retrieve numerical data (if the problem is presented in the text format, children are likely to stick to the numbers from the beginning).

(2) Narrative with realistic problems

The video adopts a realistic story with an introduction, development, turn, and conclusion; not explanation-type material provided by so-called TV teachers. It is effective to anchor a problem to be solved to a realistic context, raising reality and verisimilitude. Table 4 illustrates problems casted to children at the end of each of the 6 episodes of the Jasper series. The table indicates that those problems are also likely to happen to children of the target age group. As the general structure of the story is easy

to understand and familiar to children, children will clearly be shown the ways to use problem-solving methods of arithmetic learned in the Jasper materials in an everyday context. Accordingly, children will easily recognize the usefulness of math skills, and will more frequently use math as a tool.

Table 4 Six Episodes of the Jasper Story and Problems Presented at the End

Number of episode	Title	Problem presented
<Trip plan (time, distance, speed)>		
1.	Journey to Cedar Creek	Can Jasper return home by sunset? Reaching home without running out of fuel by going downstream in a boat Jasper bought.
2.	Rescue at Boone's Meadow	What is the quickest way to rescue? A wounded eagle was found in the camp. It needs to be treated at the veterinary hospital immediately.
<Project plan (statistical data)>		
3.	The Big Splash	What is the most profitable plan? Want to make a profit preparing a business plan to hold a game of dunking teachers.
4.	A Capital Idea	What is the most profitable plan? In order to earn the cost of a class trip to Washington, recycling activities are planned.
<Finding a route (Geometry)>		
5.	The Right Angle	Where is the cave? Had to search for a cave where the treasure of a Native American girl’s family lies
6.	The Great Circle Race	Who will win? What is the winning time? Various people try the race which they can start anywhere outside of the 5-mile circle.

(3) Generative format

Although the conclusion of the story is recorded on the reverse side of the video disc, children cannot see it until they solve the problem by themselves. Without copying the model answer, they have to independently find what information to obtain to solve the given problem and generate the answer. In other words, let them experience generative learning. One of the expected advantages is that this approach motivates children.

Behind the idea is the fact that children want to decide the conclusion by themselves. The other expected advantage is that it encourages children to participate actively in their learning process.

(4) Embedded data design

Data required for problem solving (numerical data) are all embedded in various parts of the story, and seen while children are watching the video. This method, being unique to this project, enables children to retrieve information embedded in the video, independently generate the problem, and find relationships among data, playing the characters of detectives in a mystery story.

Table 5 shows the number of numerical data embedded in all six episodes of the story, that of actual necessary data in the process of problem solving, and their percentage. The average number of embedded data is 51.7. Among them, the percentage of effective data is 41.3%. As not all data are effective, skills to collect only the required data are to be mastered.

Furthermore, the children are required to generate some subordinate problems and collect the required information in the process of problem solving. During that process, they can experience change in the usefulness of data depending on the subordinate problem to be solved. Embedded teaching episodes are added as long as the realistic context remains natural, and children can refer to them as needed in the same way as the numerical data.

Table 5 Numerical Data Embedded in the Story

Number of episodes	Number of numerical data	Number of effective data	Percentage of effective data (%)	Number of formulas
1	44	17	39	16
2	42	19	45	40
3	47	25	53	35
4	34	16	47	16
5	70	19	27	14
6	73	32	44	30
Average	51.7	21.3	41.3	25.2

(5) Problem complexity

The Jasper materials intentionally provide complex problems. All episodes adopt problems that require a process of at least 14 stages (formulas) before they are solved. In some episodes, children are required to compare the two alternative solutions in order to reach their conclusion. The typical word problems of arithmetic give only the problems and required numbers. In case of such problems, children have only to select the calculation methods. The principle insists this will not develop children's logical thinking and metacognition in the problem solving process.

Table 5 provides the number of formulas, which indicates the complexity of the solving process in each of the six episodes. As the number is worked out based on the model

answers recorded on the reverse side of the video disc, it indicates the minimum number of formulas required. During the actual solving process, it is thought that children will make more formulas in many cases. This is because they may repeat trial and error, or they may reach solution methods other than by the shortest process.

As the video-based format embodies complicated problems and makes them easy to deal with, children can overcome their tendency to easily give up solving problems only after a few minutes of trial. It can achieve its aim of helping children become confident of their own potential. The problems are so complex that even teachers cannot (or so it seems) instantly fathom the solution process. It is also worth noting that this provides the classroom atmosphere that allows children to feel that they can collaborate with the teacher as one of the problem solving members, not the one who gave them correct information in authoritarian way.

(6) Pairs of related adventures

In the Jasper series, two tasks in each of three types of problem solving are provided in six episodes (Table 4). The first adventure episode, "Journey to Cedar Creek," presented the problem of planning a trip using time, distance, fuel and money as mentioned above. The second episode, "Rescue at Boone's Meadow," provides the same kind of trip planning problem in a different context. A wounded eagle should be rescued using an ultralight plane with its load within its weight limits, and without running short of fuel. For this end, children have to work out what is the fastest way, and how many hours it takes. The episode deals with the same "trip planning" problems as the first episode, and children should work out a combination of transportation (plane, automobile, and walking), route, distance and time. Children solve the problem discussing similarities to and differences between the two stories (for details, see CTGV, 1992a, p. 70).

The reason why the similar two episodes are provided lies in the promotion of transfer of acquired skills. It aims to develop the ability to tell what can be applied and what is inherent to each context comparing two episodes. From their experience of using the same skills in two different contexts, children will be able to use the skills when they face the third context that requires those same skills (activation of knowledge). The pairing of the episodes is also expected to develop this ability in children.

(7) Links across the curriculum

Laying arithmetic in instructional contexts enables the provision of information of other subject matters in a natural way in the same video discs. Table 6 indicates a partial list of activities in other subject matters suggested in the teacher's manual of the first episode, "Journey to Cedar Creek." In the same way, the second episode, "Rescue at Boone's Meadow," provides items that expand into other areas including a wireless radio, used in the rescue, which can be used to learn differences between the telephone and the wireless radio and an eagle to learn about species in danger of disappearing and conservation activities.

Table 6. Expansion of "Journey to Cedar Creek" to Other Subject Matters

Newspaper: What sections does a newspaper have? Why are advertisements important? (Activities) Make children's own newspaper; give them assignments as a press reporter: Make their own advertisements
Bicycle: Bicycle safety education and traffic rules; comparisons with automobiles (environment, health, speed)
Boat: History of boat engine development (oar, paddle, steam, propeller, nuclear power) Boat type, use, physics of boat (buoyancy, mechanism of engine) (Activities) Demonstration of paddle boat, buoyancy, propeller, and steam engine
Literature: "Adventures of Huckleberry Finn," "Adventures of Tom Sawyer," and "Life on the Mississippi" by Mark Twain, and collection of notes about travels to the source of the Missouri River written by Lewis and Clark (Activities) Read parts of the above works.
Writing: (Activities) Write down communications with visitors to Cumberland City; explain the characters to the visitors; guess questions from the visitors; guess the impression they will have. (Activities) Make resume for one of the characters. Consider what a desirable job is for him/her.
Geoscience/Physics: Influence of a river on lands; water circulation; river flow (Activities) Think of and conduct experiments on the flow of a nearby river
Radio: What is sound? How is the sound transmitted? Why can radio sound be heard? What is frequency (AM, FM)? What is the difference between shortwave broadcasting and ordinary broadcasting? (Activities) Visit a nearby radio broadcast station; assemble a radio unit; make radio program

The principle is aimed at linking various subject matters and integration of knowledge by letting children use knowledge and skills of other subject matters and in arithmetic problem solving situations. Linking and integrating items dealt with separately in different traditional school curriculum is expected to yield the following four effects (CTGV, 1993b).

1. More efficient use of limited class hours
2. Knowledge activated and used when it should be used
3. An appreciation of the concepts and methods of problem solving that can be generally used across subject boundaries
4. The ability to think about a problem from multiple perspectives.

5. Classroom instruction types adopted for Jasper materials and their determinants

In the typical classroom instruction using the Jasper materials, an episode is viewed first, and the whole class discusses ideas for problem solving. When various ideas are suggested, the class is divided into groups to solve the problem. Each group of children considers necessary subordinate objectives based on their own ideas. They differentiate between unnecessary and necessary information, collect missing data, calculate, and submit their best solution. In groups, and as a class, various solutions and their reasoning are presented. At least two hours would be taken to exchange each member's ideas in the group activity. Later, children watch the conclusion (solution example) prepared in the video disc. Children compare their solution with the model solution and check each solution's strengths and weaknesses. Expansive activities can be conducted by tackling the analogous problems using a multimedia database, etc.

In this way, children are given support in learning from failures in such a form of classroom instruction. The Jasper Project developers claim that adopting this type of instruction can only develop the Jasper material's potential to its fullest degree (CTGV, 1992a; 1993a). However, merely providing the Jasper materials to teachers does not always guarantee that this type of classroom instruction is adopted. The Jasper material itself is not what automatically changes the instruction form (so-called teacher proof material, which yields the same results whoever uses it), it is the material that can afford a change. It can promote a constructivist or situated learning approach, but it is not unconditionally guarantee to make it happen.

It is pointed out that completely different types of instruction can be given depending on the classroom instruction type the users adopt, even with the use of the Jasper materials, which is designed to support constructivist or situated learning perspectives. Table 7 lists three basic perspectives on instruction that affect the determination of classroom instruction format. It is predicted that a combination of these three dimensions generates the following three instruction types using the Jasper materials.

Table 7. Three Perspectives that Affect Instruction Type

(1)	Hierarchical ranking of instruction contents: Set mastery learning of subordinate skills as an entry condition to the subsequent learning, or consider that the acquisition of subordinate skills will not be confirmed until they are used in the context of the super-ordinate skill.
(2)	Value of failing experience: Regard no failures as desirable, or put importance on overcoming failure, limitation, or misunderstandings.
(3)	Role of teachers: Regard them as an authoritarian information provider, or regard them as advisors or collaborative learners as needed.

Type 1: Basics first, immediate feedback, direct instruction

The type 1 "Basics first, immediate feedback, direct instruction" is based on the following idea: The Jasper materials are excellent, but they require teaching all basic skills and concepts necessary to solve Jasper problems before start using Jasper; after that, the Jasper materials should be used. This type of instruction places importance on the role of teachers as the information source. In the instruction, teachers pick up each basic skill from the context, directly explain it, and allow children to practice.

When the Jasper materials are used in this way, it is anticipated that teachers lead the instruction in which an accurate problem solving process is explained to children (by sometimes questioning children about the necessary information). The weaknesses of instruction of this type are: that it takes fascinating aspects of math away from children; that it is inconvenient to teach why basic skills are important and when they are useful and; children will not always acquire the ability to combine basic skills to solve problems even if they acquire the basic skills.

Type 2: Structured problem solving

The type 2 "Structured problem solving" is based on the following perspective: The Jasper materials should be used along with learning of the basic skills; however, letting children fail should be avoided; in order to prevent confusion, worksheets should be prepared and children allowed to solve the problem based on them. Several copies of worksheets for each possible problem solution (not only for the best solution but for various alternatives including ones that are eventually unsuccessful) would be prepared. Each worksheet has blank spaces to fill in information for obtaining necessary information after watching the video or data, establishing formulas and calculating them. The more detailed the process described on the worksheet, the less frequently children fail.

In the instruction, a different worksheet is allocated to each group. Then, the groups fill in the blanks of their sheet, make a presentation for each solution, and compare them (for examples of worksheets, see CTGV, 1992a, p.75). The failures that can be avoided are those in the process that generates (subordinate) problem solving and those in the process that evaluates appropriateness of the adopted problem-solving process. This will take away from the children the work that is said to be the most important in the problem solving process. It is observed and reported that the group activities concentrated on the collection of factual information and calculation from the video with minimum ideal exchange in the experimental instruction of this type of learning (CTGV, 1992a).

Type 3: Guided Generation Model

The type 3 "Guided Generation Model" instruction is based on the following perspective: The Jasper materials are to be presented to children from the start; by letting children generate ways to solve a problem through trial and error in group activities, the richness of Jasper materials, which does not have any specific process of problem solving, will be utilized to the maximum extent. In this type of instruction, directions from the teacher should be limited to the minimum in order to raise awareness of the "exploration collective" of the whole class, including the teacher. Teachers give advice as needed. However, they should focus on not telling them the correct answers, but giving clues so that children can reach a correct answer by themselves by preparing scaffolding. The amount of support should be gradually reduced

so that children eventually will become able to work independently.

This model is recommended by the Jasper Project developers. However, its success heavily depends on teachers. They also admit that they took considerable time and effort in trying to change the classroom culture in that the model demands more than the ordinary level of classroom instruction from teachers (CTGV, 1993a, p. 64). The Jasper Project also focuses attention on how to develop teachers' capabilities, or how to establish support systems to instructional implementation. The following six points are to be noted (CTGV, 1993a).

1. Change the role of teachers from information providers to coach/co-learners, and change the inter-relationship in the classroom.

2. Give flexible and impromptu responses, as it is impossible to prepare detailed instruction plans beforehand.

3. Adopt attitudes to learn together and ones to indicate how to search for the information, as it is impossible to be an expert in all problem areas that are diffusively generated.

4. Acquire timing and methods to give appropriate support that is not too directive.

5. Acquire access skills to database in order to deepen understanding of tasks the children want to pursue.

6. Coordinate the Jasper materials and compulsory learning items, and position the Jasper materials in the current curriculum.

6. Jasper materials and anchoring instruction to a realistic context

Past instruction design models have proposed selecting media that are able to anchor the instruction to a minimum required realistic context from a perspective of efficient achievement of leaning objectives in the cognitive domain. Recently, integration of the cognitive domain and the affective domain has been attempted, and the development of motivation for learning has drawn more attention. Accordingly, generating more realistic effects of media is being reconsidered. In such cases, as reality is regarded as means to promote learning that is expected to be generated, what the reality is for and if it is feasible in the realistic limitations are always questioned.

The Jasper materials try to raise children's motivation for problem solving as well as to help them recognize the usefulness of the arithmetic problem-solving skills they are learning and acquire knowledge of where those skills can be applied through reproducing a realistic context using video. This means that the acquisition of relevant knowledge and "transfer" are also aimed for as learning objectives as well as the acquisition of individual basic skills. The acquisition of the relevant knowledge gives children a sense of satisfaction, and transfer raises the ability of skill application. Dick, who reviewed the Jasper Project from an instructional design theory, took up the pairs of related adventures (the 6th design principle) as an attractive principle (Dick, 1993). He commented that giving opportunity to apply newly acquired skills raised the possibility of transfer, and the principle could prevent mixing just learning the solution by heart in the learning of the first episode with having learning outcomes.

On the other hand, the issue of efficiency cannot be ignored when we think of developing instruction that takes up realistic topics, focuses on children's trial and error, and actively involves the then derived problems. It is true that the Jasper Project's outstanding effects have been confirmed. The utility value of the project that has know-how of making monotonous instruction attractive is also high. However, it seems very difficult to produce an effect within the limited number of class hours actually given in school education, as past discovery learning methods could not gain the expected popularity due to the issue of efficiency in instruction hours, or the development of CAI materials could not gain popularity due to the issues of equipment and development costs.

Regarding the issue of efficiency and reality, the fact that the evaluation experiment of the Jasper materials reported that higher level learning was additionally attained without impairing acquisition of basic arithmetic concepts (as mentioned in 5) offers hope. In thinking of introducing the Jasper materials to the current curriculum, examination of both gains and losses will be of help. In cases of spending fortunes on developing instructional materials, it is important to make cost-effective products, or make efforts to lower the development costs per use by producing easy to share or popularized materials. The Jasper materials have the following strengths: (1) Children can take time to watch a video many times. Using the disc as an initiating agent, various other kinds of learning can be developed. (2) The possibility of using the material in various ways enables teachers to design instruction according to their personality or instructional philosophy. (3) It has a system to provide elaborate support for the recommended way of use. Furthermore, it gives special attention on "the efficient use of limited time" as the effect of the design principle 7 (Links across the curriculum). Elaboration is seen in the Jasper materials to give opportunities for children to attain learning objectives in the other subjects as well as arithmetic while they are engaged in the Jasper materials. This point will be of some help in the future curriculum planning of combined subject matters and comprehensive or integrated study.

7. Reality from situated learning perspective and classroom learning

Young, who is one of the researchers engaged in the Japer Project, points out that the classroom learning context at school is isolated from the context of the real world where knowledge and skills acquired at school are applied (Young, 1993). In classroom learning, the principle of competition works among classmates, instruction contents change every hour after school bell according to the schedule, and the only (or major) source of information is the teacher. On the other hand, in the real world, information is dispersed from various sources. One has to form knowledge in cooperation with other members who have different specializations, selecting data from among various sources judging their effectiveness under changing circumstances. Young points out that even if it is explained to children that learning at school will be useful in the future, there is satisfactory learning, and basic skills are mastered, knowledge acquired in the classroom context is not always able to be applied in the realistic context.

The Jasper materials are developed from so called constructivism and situated learning perspectives, so that it is said to have made various efforts to make the learning context more realistic. In theses related to Jasper, the following expressions are frequently seen: "promote active knowledge building," "authentic task," "let children participate in an apprenticeship system in the learning context," "authentic use of mathematical concepts," and "help them understand how experts use their knowledge in the real world." The term "anchored instruction" was proposed by CTGV as one of the instructional models for the purpose of

promoting situated learning. The term was adopted by AECT as its technical term and defined as below: An anchored instruction is referred to as a technique that situates instruction in various real (in many cases, realistic) scenes in order to support reflection, transfer, or the process of advanced problem solving（Seels & Richey, 1994, p.125）.

While Tripp, who tried reviewing the Jasper materials form a situated learning perspective, highly appreciates the value of the Jasper materials, he insists that what they are doing is not situated learning. What they are teaching is not a problem solving, either (Tripp, 1993, p.75). Tripp explains this in more detail below. Situated learning should anchor the social context of the real world. There is no possibility of anchoring the simulated video stimulation. In situated learning, skills are stolen by watching experts solve problems in a real context. Letting children solve problems does not present a dilemma for them. Furthermore, what the Jasper materials teach is not problem solving referred to by the advocators of situated learning; rather, it is critical thinking. In the Jasper materials, skills of building and examining propositions through analysis of a given scenario, not how to row a boat or how to rescue an eagle, are going to be taught. From a perspective of situated learning, the problem solving should be carried out dealing with real things in the real world, and it is not a skill to be transferred. Problem solving in that sense could not be learned anywhere else. It is a skill easily acquired by anyone. Very critical thinking should be, in reverse, taught at school. An adventure story is for the purpose of letting children learn critical thinking in a more animated way. It is not necessary to teach what the situated learning advocators call problem solving.

As Young points out, even if the learning context in the school classroom is isolated from the real world, it is a hasty conclusion to make efforts to change school arithmetic into a simulated experience of arithmetic on the outside world under the name of the situated learning. Even if classroom learning is anchored to a realistic context only because reality is lacking in classroom learning, it will not always lead to the attainment of situated learning. According to Lave and Wenger, “School organization as one of the educational forms is based on the point of view that knowledge can be decontextualized. Furthermore, school itself is a social system, so that it forms an extremely special context as the place of learning (Lave & Wenger, Saeki, trans., 1993, p.16).” If we think so, it is necessary to examine what the special context is in the school situation. In the words of Tripp, school is a place that teaches critical thinking rather than problem solving, and it has, or must have the context for teaching critical thinking.

Miyazawa, who takes up the school context from a historical perspective, points out that medieval teachers as the senior workers used to instruct children as their successors in how to copy texts, decode them, write notes about, and make documents. He describes the specialty of school as below. “The modern school teachers have a difficult role (because their relationship to children is not that of the senior and the younger that share the same work that forms the theoretical foundation for the authority of adults). Teachers cannot expect children to share vocational awareness that should have strongly motivated their learning. Under the adverse conditions in which it is difficult to adopt the most familiar learning form, or apprenticeship, teachers had to teach something (p.167).” If most children are successors of the teacher, or aiming to be teachers, the apprenticeship system can be applied to the school environment. The problem solving referred to by advocators of situated learning is learned then. However, it is not the goal of modern schools to “find miniature teachers in the children (p.169)” setting teachers as desirable adults, or to develop a person like a teacher. Accordingly, it is impossible to adopt an apprenticeship system directly.

From a situated learning perspective, it is clear that the school has a special context. Nevertheless, it is not designed to develop a successor to those who live in such special context. However, school will not function if school becomes closer to a context other than school. According to Tripp, the adventure story is for the purpose of letting children learn the critical thinking in more animated way. It is not necessary to teach what the situated learning advocators call problem solving. Rather than discussing whether or not the Jasper approach is situated learning, Tripp's idea may be the way to utilize the advantage of the Jaspers material to the maximum extent.

Conclusion

This article introduced the Jasper Project in detail. The major trends in the U.S. are ever-increasing school reformation theories and reviewing of school education including many experimental trials, and reconsideration of theoretical frameworks from constructivist or situated learning perspectives. On the other hand, practical works of instructional material development as in the Jasper Project are steadily being carried out. Those practical materials and instructional implementation give feedback to the discussion of school reform issues and reconsideration of theoretical frameworks. It is a good example of the tradition of realization of empirical research. It gives many suggestions not only for material development, but also for what a school should be and changes in the roles of teachers (Suzuki, 1995).

As pointed out in the article, using the Jasper materials does not automatically change the nature of instruction. However, it is true that it gives opportunities to reconsider many things including the isolation of contexts of classroom instruction and the real world, the implicit premise of instruction, the abilities designed to develop in instruction, and so on. Discussion on specific material is being actively discussed based on members' mutual learning philosophies and instructional philosophies. It is significant that the Jasper materials provide initiating agents for those discussions.

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Anchoring Classroom Instruction to a Realistic Context:: The Jasper Project as an Example

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This article reviews Vanderbilt University's Jasper Project in detail, in order to explore the possibility and problems of anchoring classroom instruction to a realistic context. Six adventure stories and seven design principles are first introduced, along with data from their evaluation study. Three possible ways of using the Jasper series are then examined including their underlying views of instruction, and new roles of teachers under the Guided Generation Model, the advocated model for Jasper instruction. Critiques of the Jasper materials from the instructional design viewpoint and that of situated learning are finally summarized, in respect to the 'reality' of the context of classroom instruction.

Keywords: instructional development, math education, videodisc, Jasper Project, instructional context