Effect of Instruction on Primary School Science Subject: Awarded teachers vs. General teachers

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Abstract

Creativity is the core of the processes in learning how to learn and in coping with changes and future new education (Torrance & Goff, 1989). This study investigates the effects of instruction of awarded teachers and general teachers on students' learning performance. The criteria for creativity used in this study is based on a Consensual Assessment on the assessment of product by Amabile (1983;1996). Subjects in this study include: 1) 3 primary science teachers, as the creative instructor group (treatment group), selected from those who had been awarded more than three times in National Science Competition for the last five years (1996-2001), and 2) 3 primary science teache rs, who have never joined national science exhibition, as the contrast group. The instruction processes for grade 5 primary students (instruction belief, instruction styles, teacher-student interactions, and assessment types) between instructors of treatme nt and contrast groups were video recorded, observed, and interviewed for comparison. In addition, learning performances in science subject between students in treatment group (3 classes, a total of 102) and those in contrast group (3 classes, a total of 105) on Science Subject Learning Achievement, the Creativity Thinking Test by Wu (1998), which includes 'Bamboo chopsticks ' (verbal), and '? ' (figure), and the Creative Problem Solving (Form B) produced by the researcher of this study, were compared. The results indicate that in their design of teaching activities, and the selection of teaching materials in the instruction processes, teachers in the treatment group, as influenced by their long term engagement in scientific research, demonstrated more self assertive in ideas immersed with practical life issues, and stressed on new ideas in interpretation. As in the contrast group, teachers follow to a great extent the Teachers' manual (instruction guide) in their instruction. In the instruction styles, teachers in the treatment group prefer Socratic dialogues, students' personal observation, discovery, inquiry, expression, and group discussion, while teachers in contrast group mainly give lectures, and stick to conventional class instruction. In assessment, teachers in the treatment group adopt more varieties of

measurement, which include students' independent studies, than those in contrast group. What is more, in students' learning outcome, students receiving instruction of treatment group demonstrated superior performances on verbal-fluency, flexibility, originality, and figure-fluency, originality, as well as problem solving (observation-discovery, analysis-solution) to those receiving instruction in the contrast group, despite the fact that differences in acquiring science subject knowledge between students in both groups are not significant. The present study further proposes a few suggestions with discussions.

Purposes

With the rise of information technology, worldwide web and the advent of information based economy age, the emphasis on innovation, creation, and invention has marked national competitiveness. Cultivation and research as well as development of innovative human are the prime goals of school education and enterprise development, and have become the focus of education reform in Taiwan (Education Reform Advisory Council of Executive Yuan, 1994; Ministry of Education, 2002; Executive Yuan, 2002; Fryer, 1996; Howe, 1996; Secules, Cottom, Bary & Miller, 1997; Torrance & Goff, 1989). From the perspective of constructivism, such an endeavor is to make sure that students are able thinkers to question and explore about critical problems, and become life long suitor and integrator of advanced knowledge(Richetti & Scheerin, 1999).

Quite a few studies also find that teachers' thinking and instruction behaviors will affect students' development of thinking ability (Barell, 1991; Clark & Peterson, 1986; Costa, 2001; Houtz, 1990; Howe, 1996). A correlation study of creativity, instruction style, and student control on 60 India senior high school teachers in a Teachers' college by Raina and Vats (1979) finds that the instruction style of teachers of high creativity facilitates students' creative thinking more than that of teachers of low creativity, and more humane on student control. Baker (1979) studied the effect of teachers' creativity on students' creativity with 26 teachers (2 males, 24 females, aged 23 to 60) and 705 pupils from grade 3, 4, to 5 (348 males, 357 females) in 2 suburban and urban schools in Philadelphia and found that teachers of high verbal creativity facilitated their students' flexibility, originality, and general verbal creativity. Gallagher and Aschner (1963) indicated from their studies that teachers were the role models and the sources of identity to their students, and such roles might affect their students and trigger divergent thinking. Therefore, the creativity of teachers becomes the tool to stimulate creativity behavior. Results also confirmed that teachers' overall performances of thinking were similar to those of their students. Besides, Flanders clearly indicated in his study (1951) that teachers' acceptance, inquiry orientation, supportive behaviors might promote students' inquiry orientation, anxiety reduction, complete or occasion emotional readjusting behaviors, which are the pre-requites of stimulating creativity. In a similar study by Hausen (1969), teachers with high creativity (the highest 20% on TICT) were found to accept or use students' ideas significantly more than those with low creativity (cited from Baker, 1979, p.21-22). Measel and Mood (1972) studied the relationship between teachers' direct, indirect verbal behaviors and the teacher-student interactions on thinking with 15 female teachers and 399 pupils of 2nd grade (214 males, 185 females) in 3 communities of southeastern Michigan, and found that students in teachers of high thinking group were significantly superior to those in teachers of low thinking group on behavior responses of employing higher level of thinking. Richetti & Sheerin (1999) pointed out that good questions could inspire thinking and creativity, and prompt the awareness of the importance of students' inquiry. There are two common inquiry models and strategies---Socratic questioning and Bloom's taxonomy. Ncecil cited the study of Carin and Sund in his research in 1995 and confirmed that when students were encouraged to develop skills in critical and creative problems, and were provided with opportunities of conclusive dialogues with their peers on information from different perspectives, they could significantly acquire higher level of thinking. Besides, a few studies also indicated that providing students with the learning environment in which they had enough time for creative thinking, and encouraging their creative thoughts were helpful to the cultivation of thinking ability. Cheng & Wang (2002) conducted an intensive interview on 36 awarded teachers who had been awarded more than three times in science competition of junior high and primary schools from 1994 to 1998, and compared the response differences of 224 general and awarded teachers on Creativity Development Scale. They found that awarded teachers in science competition possess a lot of common personal traits and abilities contributive to creativity, such as extensive interests, adventurous attempts, unbiased attitudes without being confined to conventional approach, persistence in problem solving, inquisitiveness, optimism, perspectives from different angles, and assertiveness. When they were conducting course unit instruction, they basically followed the unit goal, editing the content of the instruction by themselves, or through discussion and cooperative learning. Some teachers conduct their instruction through concept map to explore students' ideas, while others stress the process of exploration from the perspective of scientific development to help students learn scientific concepts. These teachers even used casual scientific phenomena such as meteor rain, eclipse by Mercury…etc., to conduct their instruction, and students were asked to express their opinions, to inquire on web sites, and to form a question to be answered through observation. For example, when it comes to earthquakes, the questions like: types of quakes, their factors, resulting damage, predictability…etc.. Or these teachers may use phenomena that may interest students around their living environment, such as the permutation of caterpillars on tree leafs, the ever growing floating lotus leafs…etc, to form questions for independent study and instruction.

Since school education is the cradle for cultivating the basic discipline of experts in technology, the researchers of this study further explore, on the basis of previous studies, the actual classroom instruction activities of these awarded primary school science teachers with high level of creativity, from a consensual assessment on product by Amible (1983, 1996) as criteria for creativity performance, or from the evolutionary perspective and the gatekeeper in the field by Cskszentmihalyi (1988, 1996), to analyze how these teachers display their creativity in the process of instruction, and how instruction activity influences students' creativity performance, problem solving ability, and the learning of science subjects. Such an attempt is valuable for school education in response to the global promotion of enterprise innovation, creativity cultivation, and national competitiveness, which is also where the research interest of this paper lies.

To be specific, this study attempts to conduct knowledge management on innovative knowledge, thinking processes, and products of awarded teachers in science competition, and to establish their teaching portfolio as the reference for research and development in the curricular and instructional design on cultivation of science creativity. There are three main purposes for such an attempt: 1) to compare the instructional differences between awarded teachers in science competition (treatment group) and general teachers (contrast group), 2) to coordinate with the assessment of students' learning behavior, and develop scales for scientific problem solving, and 3) to compare the differences of students under two different teacher groups on their science knowledge or concept , creative thinking and the ability of problem solving.

Research Method

Research sample: 1)on teachers: 6 primary school science teachers, divided into treatment and contrast groups, with treatment group 3 female awarded teachers who were awarded more than three times in science competition from 1996 to 2001, with teaching years 22, 25, and 23 separately, while in the contrast group 2 female and one male general teachers, with teaching years 20, 22, and 1, separately. 2) on students: 207 pupils of 5th grade in primary schools (102 treatment group, 105 contrast group) in 6 suburban and rural areas in Kaoshiung, and these pupils were all under the instruction of teachers being studied.

Research instrument: the instruments for collecting students' performance in this study include the revised Creative Thinking Test, course knowledge and concept test, and problem solving test.

1. Revised Creative Thinking Test: produced by Wu and others (1998) in which three scores on 'fluidity,' 'flexibility,' and 'originality' are derived from two subtests, namely, 'bamboo chopsticks', and 'figure ? ,' which serve as the index of students' creative thinking.
2. Course knowledge and concept test: this test was originally produced by the research group according to 5th grade science curriculum in primary schools, but there were different versions of textbooks, with different units, adopted by these 6 teachers, so an identical and

unified content of the test was not plausible. In this regard, the grade on the science subject for the semester was used as the index for students' cognitive performance in science subject.

3. Problem solving test B: This test was developed by Cheng, Wang and Chou (2002) according to the Creative Problem Solving Model by Parnes (1991). There are four problem solving processes evaluated and induced from students' observation ability, cognitive ability (problem representation), analytical ability, and creativity (implementing the solution process), which may be explicated below:

Observation: to observe problem situation and discover facts. Subjects were asked to read in detail the graphs and descriptions and answer the test items based on their observation.

Definition: to discover the problem and to decode it. Subjects were asked to point out the key points in the situation based on their observation.

Analysis: to conduct the induction of information and to analyze it. Subjects were asked to propose information or causes with concise scientific concepts.

Solution: to propose solution projects and to implement them. Subjects were asked to propose plausible solutions with theoretic basis in the problem situations of each problem sets.

In each of the processes, there are 8 items, 32 items in total, the internal consistency: .8543 is derived from 284 pupils of grade 5 and 6, with correlations among these four processes: .529~.712, correlations with total scores: .778~.898 ($p<.01$), correlations with problem solving test A: .559 ($N=146$, $p<.01$). This test boasts its good reliability and validity, and can be used to measure students' ability of applying their science knowledge, observation and analytic abilities to problem solving in their daily lives.

Procedures of implementation:

This study was conducted (from January 10, 2001, to the early June, 2002, 9 months in total) by research assistants according to the deal made by the teachers being studied. The unit instructions conducted by these 6 teachers were video taped and interviewed.

The contents of interview mainly include: (in addition to the basic personal data of interviewees)

1. Name, academic credential, and years of teaching?
2. Sir, what's your personal interest? What are the preferred fields in the common natural science information? Where did the information that you touch on from? (e.g., science magazine, or Discovery channel programs)
3. Sir, what are the factors that you think might directly or indirectly affect your instruction styles and thinking modes? (family background, academic history, conferences, training programs…etc.)
4. Would you share with us, sir, the ideas of the instruction today? Why should the curriculum today be so?

(lecture, discovery)? What are the considerations for these?

5. What do you think is the main instruction goal of this unit? Are there any important ideas? Is there any confusing myth concept? How to avoid it in instruction? Do the responses from students meet your expectation?
6. Sir, would you please tell me how you feel about the different instructions such as lectures, experimental manipulations, and discovery?
7. What are the tips or knacks, or pros and cons of such an instruction? Are there any stud ents that fail

that fails to follow such an instruction? What kind of students? Why?

8. Sir, what are the important elements of creativity or creativeness? Can you offer your perspectives? If we apply creativity to instruction, what are the creative instructions? What is the criterion for instruction? What are its special elements?
9. Ask teachers to express their own ideas about whether their own instruction is creative. If a 10-point scale is used, what point will the teacher think his own creative instruction be?

The administration of students' creative thinking test and problem solving test were completed around the end of May,2002, and the grades of science subject were acquired from science instructors at the end of the semester.

Statistical Analysis: the data collected in this study were treated, in addition to descriptive statistics, through t-test for students under different treatments on their differences of subject knowledge, one-way ANOVA to test the difference between problem solving and creativity (a was set on 0.05, but to reduce type I error on posterior comparison, a was then set on 0.01).

Results and Discussion:

1. Comparisons of portfolio between different groups of teachers:

The study videotaped the unit instruction and interviewed the awarded teachers in science competition (treatment group) and general teachers (contrast group) through case study approach. According to the instructional processes of teachers, we compare the differences of instruction approaches, instruction specialties, assessment modes and teacher-student interactions. The results indicated that teachers in treatment group showed more assertiveness and more immersions with live issues in the choice of materials, demonstration, and instructional activity design, with emphasis on new concepts for change in their instruction interpretation, which are affected by their long-term engagement in scientific research, while teachers in contrast group conducted their instruction by following Teachers' manual (instruction guide). On instruction style, teachers of treatment group favor adopting Socrates' dialogues, stress on students' observation, discovery, asking questions, and group discussion, while teachers in contrast group conducted their instruction through lectures, and emphasis was largely placed on class regulations. As to the assessment of students' performance, teachers in treatment group adopted more variety of modes of assessment, including independent study.

2. Differences on science cognition, creativity, and the ability of problem solving:

1) Differences on creativity in students of the two groups

As indicated in Figure 1, there was a significant difference on the total score between groups in The Revised Creative Thinking Test (Treatment group: N=99, M=62.12, SD=24.74; Contrast group: N=101, M=50.17, SD=20.16; F=14.06, p=0.000.)

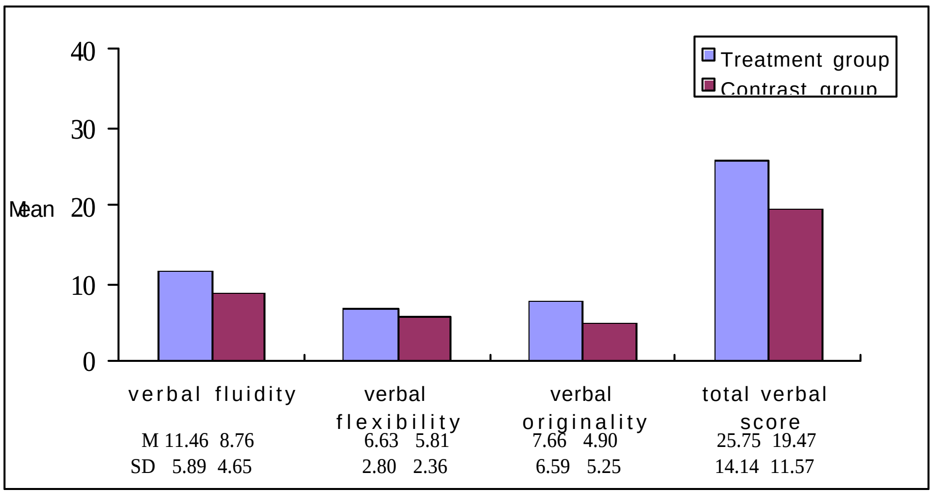

Figure 1: Differences on figure creativity in students of the two groups

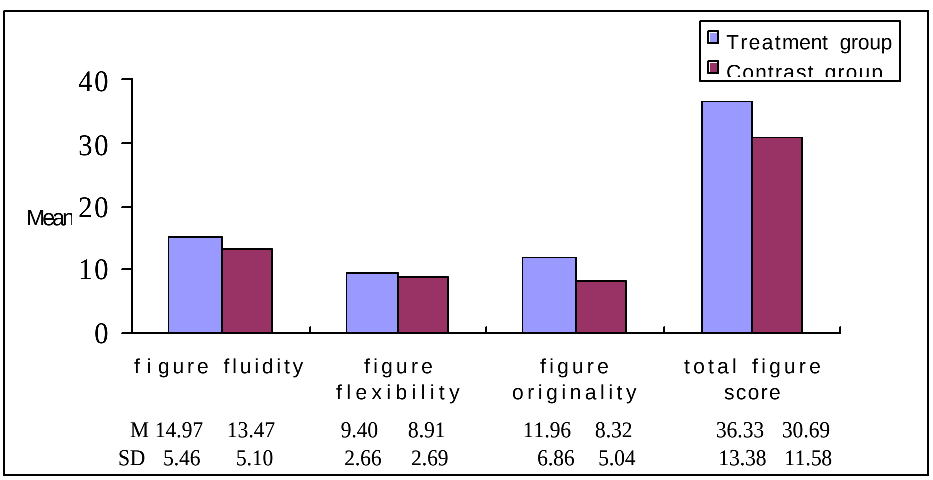

Figure 2: Differences on figure creativity in students of the two groups

The creativity performance of students in the class of awarded teachers was significantly higher. As to the total verbal score (bamboo chopsticks) (F=11.85, p=.001) and total figure score (?) (F= 10.20, p=.002) both indicated that the creativity of students in the class of awarded teachers was significantly higher. As to the three indexes in creativity: fluidity, flexibility, and originality, the verbal fluidity of students in the class of awarded teachers is significantly higher (TP: M=11.46, SD=5.89: NT: M=8.76, SD=4.65) and verbal originality (TP: M=7.66, SD=5.25; NT: M=4.90, SD=5.25; Wilks' ?= .932, p=.003.) Besides, students in the treatment group were significantly superior to those in contrast group on figure originality (TP: M= 11.96, SD=6.86; NT: M=8.32, SD=5.04; Wilks' ?= .906, p=.000.)

2) Differences on problem solving ability in students of the two groups

As indicated in Figure 3, there was a significant difference on the total score between groups in The Problem Solving Test by researchers (Treatment group: N=102, M=37.52, SD=7.14; Contrast group: N=105, M=33.45, SD=8.63; F=13.56, p=0.000.) The ability of problem solving of students in the class of awarded teachers was significantly higher. As to the four indexes in problem solving: observation, inquiry, analysis, and solution, students of treatment group on observation (TP: M=10.51, SD=2.09; NT: M=9.47, SD=2.59) and analysis (TP: M=8.49, SD=2.54; NT: M=7.05, SD=2.93) were significantly superior to students on contrast group (Wilks' ?= .919, p=.002.)

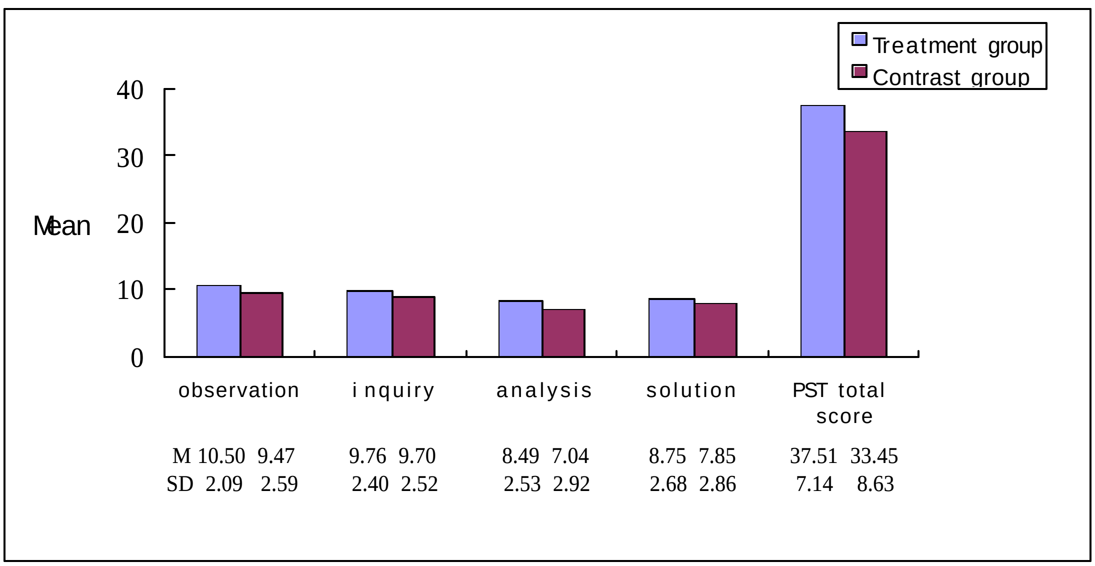

Figure 3: Differences on problem solving ability in students of the two groups

3) Differences on science cognition in students of the two groups

As indicated in Figure 4, this study used the grade of natural science subject as the index of students' science cognition, and by t-test, the result indicated that there was no significant difference (t= -.914, p=.362) between treatment group (M= 88.94, SD=9.26, N=102) and contrast group (M=87.70, SD=10.30, N=105).

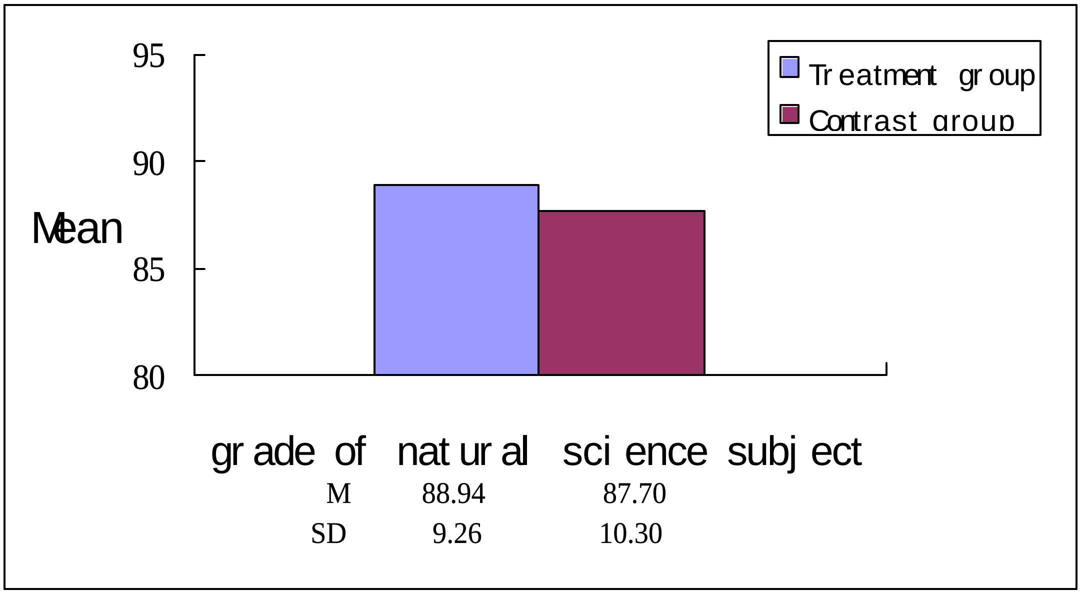

Figure 4: Differences on science cognition score in students of the two groups

According to the above research results, those primary science teachers who were involved in science competition for a long period of time were engaged in instructional design and teaching behavior. As Clark and Peterson put it (1986), teachers' thinking, planning and decision-making form the main part of psychological environment for instruction. In the teacher-student instructional situations, curriculum is interpreted and judged. Teachers' behaviors are directly influenced, ruled and even controlled by teachers' thinking processes.
This group of awarded teachers in science competition use Socrate's dialogues as a guide through efficient problems (Richetti and Sheerin, 1999). Instruction is like problem solving, and creation and imagination are used to produce brainstorming, new ideas are produced in thinking and are also used to make generalization and prediction after data collection (Lin & Lederman, 2002), to direct students to redefine problems, to show their ideas, to tolerate ambiguous situations, etc. (Sternberg, 2000). Through Communication, group discussion, and the encouragement of asking questions, they can change their classroom environment in the instruction processes at the same time and establish creative class atmosphere (James,2000). These teachers, as in Fryer and Collings' research on British teachers (1991), believed that their creativity could be developed. To put it more appropriately, these awarded teachers in science competition regard teaching as a creative work, as from Sternberg (1999), Stermber, Haufman, and Pretz's viewpoint in 'A propulsion model of kinds of creative contributions', attempting to use their creativity to achieve what the creator assumes it to be. In other words, they try to use creative teaching as a platform to promote students' ability of thinking and

creation, especially of verbal fluidity, verbal originality, figure originality, and the abilities of observing problem situations, of analysis of information, and of discovery of facts and problems in the problem solving processes. The results of the research generally supports the studies in literature (Baker, 1979; Measel & Mood, 1972; Raina & Vats, 1979; Richetti and Sheerin, 1999). The study also provides positive evidence for teachers' thinking and instruction behaviors that are helpful to students' acquisition of the ability of higher level of thinking.

Still, the instructional impact of awarded teachers did not differ significantly from that of general teachers in the study, partly because of the different versions and contents of the textbooks, or the identical items for the test. Other factors such as the motivation of instructors, especially those of contrast group, may also counteract the result in that these teachers chose to direct students (as the contrast group) in their instruction based on their expertise and professional training, which may, to some extent, secure the quality of the instruction. Or, the differences between students of these two groups were not significant in the very start. Finally, whether it is appropriate to evaluate students' learning performance through grades on science subject is a question, and is worth further experimental exploration.

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