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ABSTRACT

This study developed a method to assess group process in a collaborative problem-solving situation. Participants were 32 fifth- and sixth-grade students. Students in seven collaborative groups worked on a two-part mathematics problem first individually, then in groups, and finally individually again. Groups engaging in behaviors that facilitated collaboration obtained higher group and individual accuracy scores on a challenging problem set. High achieving students were influential in group problem-solving outcomes. Group scores did not reflect the individual achievement of low-achieving students. Examining collaborative group process and outcomes offers a new direction in functional and contextualized assessment for school psychologists. Two appendixes contain a problem set and illustrative transcripts of student work. (Contains 33 references and three tables.) (Author/SLD)

Running head: COLLABORATIVE PROBLEM-SOLVING

Assessing Group Process During Collaborative Problem-Solving

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Abstract

This study developed a method to assess group process in a collaborative problem-solving situation. Students in seven collaborative groups worked on a two-part math problem first individually, then in groups, and finally individually again. Groups engaging in behaviors that facilitated collaboration obtained higher group and individual accuracy scores on a challenging problem-set. High achieving students were influential in group problem-solving outcomes. Group scores did not reflect the individual achievement of low achieving students. Examining collaborative group process and outcomes offers a new direction in functional and contextualized assessment for school psychologists.

Assessing Group Process During Collaborative Problem-Solving

Since the passage of the Education for All Handicapped Children Act (P.L. 94:142) over a quarter century ago, education for students with disabilities has been one of progressive transition from no services to segregated services to inclusion in regular classes (Nietupski, 1995). More recently, the Goals 2000: Educate America initiatives passed by Congress (P.L. 103-227) challenged educators to serve increasingly diverse learners within regular education programs. Position statements issued by the National Association of School Psychologists (1993 a,b) support those reform efforts. Heterogeneous ability grouping and inclusive education reforms have obviated the need for assessments designed to determine special class placements or to classify within-child disabilities. Now the interest is less about why children fail and more about how or what they fail (Linn, 1993). Reschly (1988) predicted a revolution in school psychology fueled by educational reforms. New trends in assessment are shifting focus away from inferences about the psychological characteristics of children (e.g., cognitive abilities, motivation, personality) toward measures of the actual educational performance of children (e.g., achievement, functional skills, independence). Direct measures of student performance in realistic school contexts allow for low-inference, data-based educational decision-making and tighten the link between assessment and classroom practices.

Collaborative learning, that is, students learning by interacting with each other rather than only with the teacher, has gained widespread acceptance as a strategy to manage academic heterogeneity in inclusive education settings (Cohen, 1994; Slavin, 1983 a,b, 1990). Theoretical support for collaborative group work comes from social constructivist (Vygotsky, 1981) and generative models of learning (Wittrock, 1989) which assume that interaction among children facilitates concept-learning and problem-solving. Pragmatically, the interpersonal skills needed to collaborate with diverse groups are recognized as important competencies for students preparing to enter the workforce (SCANS, 1991). The growing reliance on student collaboration in classroom instruction (Antil, Jenkins, Wayne, & Vadasy, 1998; Webb, 1997) demands an assessment of the effectiveness of those instructional strategies in terms of group and individual participation and achievement. The objectives of this study were to develop a method to assess group process and to examine achievement outcomes in a collaborative learning situation.

Clark and colleagues (1996) described collaboration as a dialogue or discussion with its emphasis on group process and full participation of group members. When the goal of collaboration is learning or problem-solving, facilitative group processes may include exchanging ideas, giving and receiving help from others, clarifying strategies, resolving conflict, and encouraging others to participate. Collaborative learning is defined as students working together, without immediate teacher supervision, in a group small enough so that everyone can

collectively participate on a task. Several authors, notably Damon and Phelps (1989), have distinguished subtypes of collaborative learning models. Variously termed cooperative learning, peer collaboration, and peer tutoring, these subtypes differ somewhat based upon the demands for equality and mutuality in task engagement. Notwithstanding those distinctions, the term collaborative learning is used for of this study.

Early studies of collaborative learning focused exclusively on heterogeneous group composition with respect to achievement rather than the interaction that occurs in those groups (see Webb, 1982). Bossert (1988), in a review of the research on collaborative education strategies, was critical of studies that employed a "black box approach" (p.233) in which a collaborative instructional method was compared to a non-collaborative method on some outcome measure. Distinctions between group versus individual learning settings are not the most important, rather the specific experiences of students are more important in predicting learning outcomes. Webb's longstanding research program (1980, 1982, 1989, 1993, 1995, 1997) demonstrates that the amount of student learning in group work depends on the quality of interaction. The important question concerns the ways in which various group collaboration processes produce positive effects.

In a truly collaborative context, all individuals are actively engaged in working toward a solution to the problem (Damon & Phelps, 1989). Individuals work together by building on each other's ideas to construct understandings they did not have prior to the collaborative experience (John-Steiner, Weber, &

Minnis, 1998; Tudge & Rogoff, 1989). Therefore, the performance of students working collaboratively with others would be a valid measure of individual competence when students are actively involved in learning how to solve the problem. On the other hand, when students use the group's resources to obtain a solution or an answer without trying to learn how to solve the problem (e.g., copying another student's work without trying to understand it), scores from a group assessment context will overestimate their individual competence.

Test scores from group contexts may overestimate or underestimate students' performance in an individual setting. Group assessments that give students opportunities to collaborate may overestimate individual competence when students use resources in the group to solve problems that they would not be able to solve alone. Students with learning problems may perform better when working collaboratively, due to cognitive factors (e.g., greater intellectual resources available) and social variables (e.g., greater motivation). But negatively functioning groups may hinder performance more than individuals working alone.

One solution to the problem of obtaining valid information about group and individual performance is to examine group processes. Studies of group processes in instructional settings are necessary for understanding how groups operate and the experiences of students in them. Cohen (1994) recommended observational studies that examine processes of interaction in relationship to outcome variables in order to analyze optimal features of interaction which are important for certain

outcomes. Group process data can reveal the extent and nature of individual student participation and individual student competence as well as the nature of the group's collaboration. This study is designed to illuminate how interaction in heterogeneous groups can prove effective in assisting low achieving students.

In collaborative groups, it is expected that high achieving students will exert their influence to assist low achieving students. However, Dembo and McAuliffe's (1987) findings suggested that high-status students may maintain control in groups by discouraging the participation of lower-achieving students. Thus, groups may be "unfair" if they do not give students equal access to group resources. Inequalities in participation are troubling because participation may be linked to achievement gains (Fuchs, Fuchs, Hamlett, & Karns, 1998; Webb, Nemer, Chizhik, & Sugrue, 1998).

Webb (1980) reported that group composition in terms of ability had important effects on the nature of the behavioral norms that developed in collaborative learning situations and these norms had an important impact on group process. Norms refer to implicit or explicit rules for acceptable behavior among group members which influence patterns of participation; for instance, who can ask or answer questions. If lower-achieving students have less access to social interaction they may be deprived of the benefits of giving or asking for help (Farivar & Webb, 1994). To understand group collaboration and individual participation, it is important to assess group norms for behavior so that an individual's participation can be compared. Focusing

on student capabilities and coping strategies in specific learning situations, rather than on pathology or disability, is a significant change in the perspective of assessment.

Three practical implications of this review of the literature for school psychologists are: (1) the need to assess collaborative group processes; (2) the need to validate collaborative group and individual achievement outcomes; and (3) the need to teach students collaborative group process skills. The purposes of assessing group collaboration in this study were to measure a) group productivity, b) individual success after having had an opportunity to learn from group collaboration, and c) students' abilities to interact, collaborate with others, and function as members of a group.

Method

Participants: Fifth and sixth grade students attending a semi-private laboratory school on a college campus were recruited. Parental consent was obtained for fifty children to participate in the study. Eighteen of those children did not take part due to absences or lack of fit with the grouping parameters. The final sample consisted of 32 students assigned to eight groups. High and low math achieving students were categorized by median split on the mathematics subtests of the Metropolitan Achievement Test. Mixed gender, grade, and ability groups of four were constituted. Students assigned to one of the seven collaborative groups had not previously worked with other group members on problem-solving tasks. In addition, students rated their familiarity with each other to ensure each group was balanced along that interpersonal dimension.

Procedures: A nonequivalent control group pre- and post-test design was used. Seven groups of four students worked to solve a challenging two-part math problem (Evered, 1997) both individually and collaboratively. As a control, four students worked individually but not collaboratively to solve the math problems. The problem-set is included in appendix A. All individually administered pre-tests were immediately followed by collaborative work for groups 1 through 7 on the first day of the study. Groups took between 5 and 10 minutes to solve both parts of the problem. No feedback was given to students about the accuracy of their work. Two weeks later, post-tests were administered to all students in the seven collaborative and single control groups.

Discussion in the collaborative problem-solving groups was scored by the criteria set forth by Leach (1992) and Zola (1992). This scoring approach allows one to determine a norm of interaction in the group while evaluating an individual's participation. Examples of scoring categories include behaviors that facilitate group process (such as drawing another person into the discussion, asking a clarifying question, or communicating a problem-solving strategy) and behaviors that detract from group process (such as not paying attention, interrupting, or monopolizing). Three graduate students observed and videotaped collaborative group process during problem-solving. Facilitating or detracting group process behaviors were recorded for each student on a collaboration scoring tally sheet. Interobserver reliability coefficients for facilitating

behaviors, adjusted to account for chance agreements, were in the .80 range. Adequate interobserver reliability was not obtained in scoring behaviors that detract from group process so that category cannot be evaluated. Scores for facilitating discussion were calculated for each group as well as for individual members of each group as they worked to solve a problem set. Transcripts of collaborative problem-solving interactions and scoring protocol for groups one and seven, examples of groups scoring low and high in group process facilitation respectively, are contained in appendix B. On the transcript, statements are indexed by the number assigned to each group member (1 to 4) and by letter to indicate the sequence of the discussion. Statements are categorized and coded by letter on the collaborative scoring tally sheet.

Results

Insert Tables 1, 2, & 3 about here

Information about the composition of each group in terms of gender, grade, and math achievement is contained in Table 1. Table 2 holds the problem-solving results for the seven collaborative groups. Individual pre-test scores for both parts of the problem and group scores are reported in columns 1 through 4. In the next column, group facilitation scores are the sum of scores across all facilitating behavior categories. The final column lists the proportion of an individual group member's contribution to the collaboration--the student's individual score divided by the group facilitation score. Table 3 lists the individual pre- and post-test results for the seven collaborative groups and one control group for both parts of the problem.

Conclusions

The findings suggest that high math achieving students were active participants and presumably influential in group interaction as evidenced by high individual contribution scores. Groups obtaining higher scores on behaviors that facilitated collaboration, that is, groups 4, 5, 6, and 7, achieved higher group accuracy scores on the problem-sets. Post-test findings showed that group outcome scores did not reflect individual achievement, particularly for the low math achieving students. In particular, this trend was apparent on the more difficult second part of the problem. Several low math achieving students from facilitative groups that obtained accurate group outcomes could not recall or recalculate the solutions on the post-test. However, more students from the facilitative groups obtained accurate post-test than did students in the collaborative groups scoring low in facilitation and the control group students who worked without group collaboration. A limitation to the study inheres in the design. It is not clear whether students who provided accurate answers on post-test following the collaborative problem-solving effort actually understood the math concepts involved or simply recalled answers from the group work.

Discussion

Notable about the findings was that positively interacting groups showed greater accuracy in group problem-solving and in individual achievement outcomes. In contrast, groups with low collaboration scores did not show individual problem-solving accuracy on post-test beyond that observed with the controls who did not have the opportunity for group collaboration.

These results are consistent with previous research findings emphasizing the importance of the quality of interaction among group members as critical to the outcomes of collaboration. In terms of a substantive contribution to the literature, this study provides a method for contextualized assessment for school psychologists in this era of educational reform. The collaboration scoring tally sheet can be used to simply count the frequency of behaviors or easily adapted for use as an interval time sampling protocol. Data obtained from collaborative groups provide a basis for practical, curriculum-based recommendations for school psychologists as they consult with teachers about students' needs and classroom practices. Information gained from group process and outcome assessment offers a conceptualization of collaboration in terms of facilitative interaction behaviors which may stimulate the formulation of interventions designed to optimize the participation and achievement of children working collaboratively classrooms. School psychologists are uniquely positioned and qualified to assist in promoting positive social interactions in groups. Effective collaborative group process data can be communicated to expand the skills of teachers without experience in inclusive education or those having specific difficulties in managing the diverse needs of students.

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Table 1

Group Composition

Group	Student	Gender	Grade	Math Achievement
1				
	1	F	5	High
	2	M	6	Low
	3	M	5	Low
	4	F	6	High
2				
	1	F	5	Low
	2	M	5	High
	3	M	6	Low
	4	F	6	High
3				
	1	F	5	High
	2	F	5	Low
	3	M	6	Low
	4	M	6	High
4				
	1	F	6	High
	2	M	6	Low
	3	M	5	High
	4	F	5	Low
5				
	1	M	6	Low
	2	M	5	Low
	3	F	5	High
	4	F	6	High
6				
	1	F	5	High
	2	M	5	Low
	3	M	6	High
	4	F	5	Low
7				
	1	M	6	High
	2	F	5	Low
	3	F	5	High
	4	F	6	Low
Control				
	1	F	5	High
	2	M	5	Low
	3	F	6	High
	4	M	6	Low

Table 2

Collaborative Problem-Solving Results

Group	Student	Individual Pre-test 1	Group Test 1	Individual Pre-test 2	Group Test 2	Group Facilitation Score	Proportion Individual Contribution
1			24*		28	9	
	1	NR		44			.33
	2	NR		26			.00
	3	15		60			.00
	4	24		30			.67
2			24*		47	9	
	1	24		18			.11
	2	26		60			.33
	3	26		30			.04
	4	24		32			.52
3			24*		49	10	
	1	24		63			.00
	2	24		NR			.04
	3	24		32			.36
	4	24		60			.61
4			24*		46*	17	
	1	24		60			.58
	2	24		90			.23
	3	NR		NR			.19
	4	20		29			.00
5			24*		46*	18	
	1	24		32			.20
	2	24		60			.15
	3	24		NR			.24
	4	24		NR			.41
6			24*		46*	19	
	1	24		60			.16
	2	24		32			.07
	3	24		60			.38
	4	24		36			.38
7			24*		46*	23	
	1	24		NR			.23
	2	20		NR			.17
	3	24		46			.34
	4	24		26			.26

* Correct Answer
NR No Response

Table 3

Pre- and Post-Test Results

Group	Student	Individual Pre-test 1	Group Test 1	Individual Post-test 1	Individual Pre-test 2	Group Test 2	Individual Post-test 2
1			24*			28	
	1	NR		24	44		46
	2	NR		24	26		NR
	3	15		13	60		104
	4	24		24	30		32
2			24*			47	
	1	24		24	18		46
	2	26		24	60		46
	3	26		25	30		45
	4	24		AB	32		AB
3			24*			49	
	1	24		24	63		48
	2	24		24	NR		NR
	3	24		25	32		NR
	4	24		AB	60		AB
4			24*			46*	
	1	24		24	60		46
	2	24		24	90		46
	3	NR		AB	NR		AB
	4	20		24	29		60
5			24*			46*	
	1	24		24	32		46
	2	24		25	60		43
	3	24		24	NR		46
	4	24		24	NR		45
6			24*			46*	
	1	24		24	60		46
	2	24		46	32		46
	3	24		24	60		46
	4	24		NR	36		NR
7			24*			46*	
	1	24		24	NR		46
	2	20		24	NR		46
	3	24		AB	46		AB
	4	24		24	26		48
Control			XXX			XXX	
	1	24		24	30		45
	2	24		24	NR		30
	3	24		24	79		46
	4	NR		23	56		40

* Correct Answer
NR No Response
A Absent

Appendix A

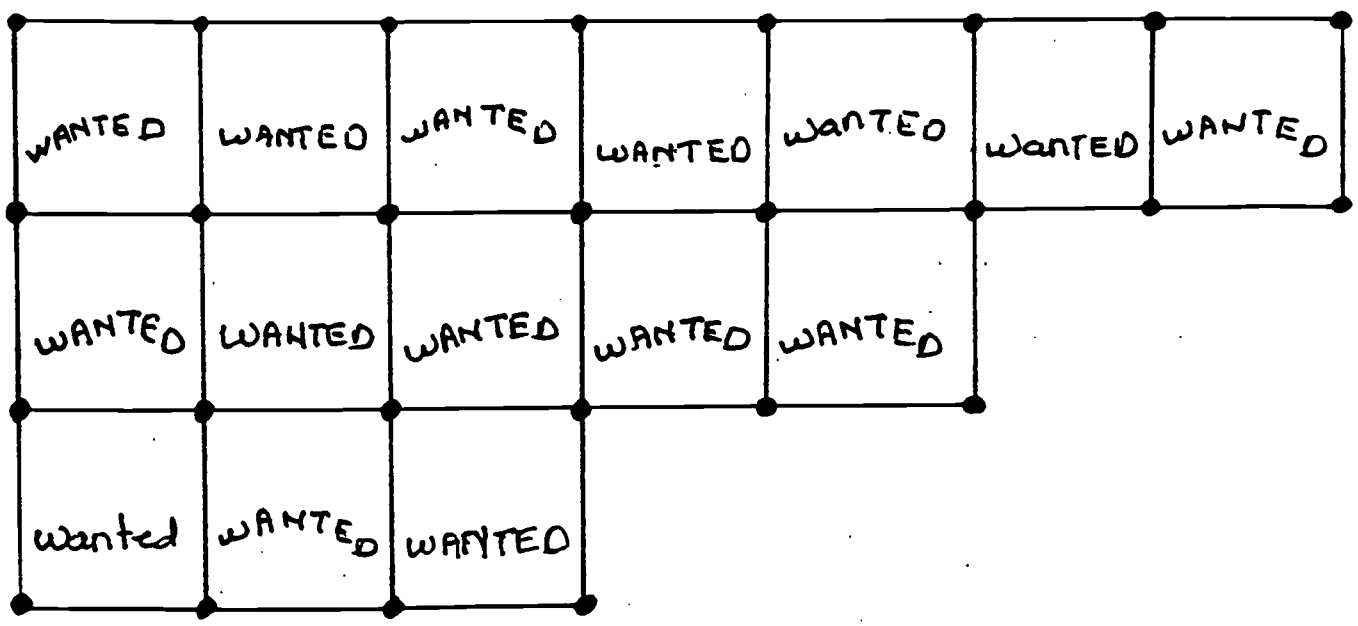
Problem-Set

Post offices throughout the nation are required to display "wanted posters" of criminals. In an effort to economize, the postmaster general ordered every post office to use as few thumbtacks as possible to display their posters. The postmaster general's directive included this illustration of a "tack-saving" display with 15 posters. Regulations require that each poster be fastened at all four corners as illustrated, and that each poster "overlap" another at least at one corner.

Rearrange the posters so that each corner is fastened without using all 26 tacks.

What would the minimum number of tacks required be?

What arrangement would require the most tacks? How many would that be?



Appendix B

Illustrative Transcripts

Collaboration Scoring Tally Sheets

Groups 1 and 7

COLLABORATIVE PROBLEM SOLVING: GROUP 1 TRANSCRIPT

* #

A - 4: We still need 4 tacks.

B - 1: Yeah, but it goes like that.

C - 4: We don't need to go like that because it still overlaps - it has to overlap 1 corner - we still need that.

D - 4: What did you guys do for 5 minutes? (directed at 2 & 3)

E - 1: They guessed.

F - 4: 1,2,3,4 . . . I can count.

G - 4: Nobody else did anything?

H - 4: What's the minimum number of tacks required?
What were the most tacks used? (reads questions from problem set)
Anybody have any ideas? No?

I - 1: If you put them is a square then you can use more tacks.

J - 4: Let's try it - you want me to put a regular square - all right - here's a regular square.

K - 4: Now -- how many rows? (directed at 1)

L - 1: All you really need to do was this -- (demonstrates on paper) - like that.

M - 4: That's what I did.

N - 4: This has 4 - that's too many - that's 15 there.

O - 4: Just do 3 down, this has 5 across - that uses less than 26 - it won't use more than 26 - You could do this - but no you could do this.

P - 4: All right - you have 15 squares there, but this can still hold another (1, 2, 3 . . .) 28 tacks - more than 26, less than 24.

Q - 1: There wasn't enough - we could have just put a line through it.

R - 4: Right (directed at 1) - no one right answer?

S - 1: We're done aren't we?

T - 4: I think we're done.

U - 4: I'm done.

* Statement Code
\# Seat Number

COLLABORATION SCORING TALLY SHEET

GROUP 1 - Refer to Transcript

Seat 1_Ila_____
Seat 2_Mark_____
Seat 3_Andy_____
Seat 4_Erin_____

BEHAVIORS THAT FACILITATE	BEHAVIORS THAT DETRACT
Communicating a strategy others	Not paying attention/distracting
S1_____ S2_____ S3_____ S4_C,O_____	S1_____ S2_____ S3_____ S4_____
Correctly applying a strategy	Interrupting
S1_I,L_____ S2_____ S3_____ S4_P_____	S1_____ S2_____ S3_____ S4_____
Recognizing errors	Incorrect application or assumption
S1_Q_____ S2_____ S3_____ S4_N_____	S1_____ S2_____ S3_____ S4_____
Drawing another into discussion	Monopolizing
S1_____ S2_____ S3_____ S4_____	S1_____ S2_____ S3_____ S4_____
Asking a clarifying question	Making a personal attack
S1_____ S2_____ S3_____ S4_H,K_____	S1_E_____ S2_____ S3_____ S4_D,G_____
Moving the discussion along	Not contributing to group discussion
S1_____ S2_____ S3_____ _____	S1_____ S2_____ S3_____ S4_F_____

COLLABORATIVE PROBLEM SOLVING: GROUP 7 TRANSCRIPT

* #

A - 4: OK - how did you do yours? (directed at 2)

B - 2: Well, what I did is I took those 2 up here and I took off the bottom tacks so they'll just keep flopping around.

C - 3: Oh no, you have to keep all the tacks.

D - 4: Oh you can't do that?

E - 3: Each one has to have 4 tacks - I guess it's 24.

F - 2: OK - so 24.

G - 1: That's just the highest - I just kept adding to the highest.

H - 4: Well there are only 20 left to use.

I - 1: Oh no, but like you can move them around to add more tacks.

J - 4: You don't move them around to add tacks, you move them around to use less.

K - 3: If we try to make it as many tacks as possible and try to use ... and figure out how many it was.

L - 4: What will require the most tacks? It will probably be this one.

M - 1: What did you get? (directed to 3)

N - 3: 46.

O - 1: Oh all right, I get it, just so diagonal on the diagonal.

P - 4: The arrangement that would require the most tacks would be this one because -- 26.

Q - 1: No, this one she made 4, no it's 26. 26 was the maximum.

R - 4: Oh, I thought it was ... cause all of them - OK so that's the highest.

S - 3: So just draw it on the back.

T - 1: No, you can just diagonal - you keep getting smaller and smaller.

U - 2: Where's the rest of it?

V - 3: The arrangement, do we have to draw that too?

W - 4: All you really have to do is draw these two.

X - 3: We can do these two here and down here.

Y - 1: Yeah, and every other one.

* Statement Code
\# Number

COLLABORATION SCORING TALLY SHEET

GROUP 7 - Refer to Transcript

Seat 1_Robert_____
Seat 2_Katie_____
Seat 3_Lia_____
Seat 4_Megan_____

BEHAVIORS THAT FACILITATE	BEHAVIORS THAT DETRACT
Communicating a strategy others	Not paying attention/distracting
S1_R,T_____ S2_B_____ S3_S_____ S4_W_____	S1_____ S2_____ S3_____ S4_____
Correctly applying a strategy	Interrupting
S1_G,O,Q_____ S2_____ S3_E,K,X_____ S4_P_____	S1_____ S2_____ S3_____ S4_____
Recognizing errors	Incorrect application or assumption
S1_____ S2_____ S3_C_____ S4_H,J_____	S1_G,I_____ S2_____ S3_____ S4_____
Drawing another into discussion	Monopolizing
S1_M_____ S2_____ S3_____ S4_A_____	S1_____ S2_____ S3_____ S4_____
Asking a clarifying question	Making a personal attack
S1_____ S2_U_____ S3_V_____ S4_D_____	S1_____ S2_____ S3_____ S4_____
Moving the discussion along	Not contributing to group discussion
S1_Y_____ S2_F_____ S3_____ _L_____	S1_____ S2_____ S3_____ S4_____

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