Learning Environ Res (2007) 10:53–65
DOI 10.1007/s10984-007-9019-y

ORIGINAL PAPER

Testing the efficacy of team teaching

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Received: 1 September 2005 / Accepted: 12 July 2006 / Published online: 13 March 2007

Abstract This study examines differences between team-taught and solo-taught sections of a graduate introductory course on research and statistics in terms of student perceptions and achievement. Factor analysis of survey data confirmed three factors: comfort with research and statistics; the relationship of research and statistics to work; and interest in research and statistics. Pre- and post-survey and achievement data were gathered, as were demographic data. *T*-test and MANCOVA results indicated: no significant achievement differences based on teaching format; a significant pre-post difference for all students on one factor (comfort with research and statistics); and only one significant difference (relationship between work and research and statistics) based on learning environment.

Keywords Collaborative teaching · Cooperative teaching · Co-teaching · Post-secondary teaching · Team teaching

Introduction

In the quest to improve post-secondary learning environments, team teaching as an androgogical tool has enjoyed sporadic attention, both historically and institutionally. Instructors and students who have participated in collaboratively taught classes enthusiastically outline its benefits as compared to solo-taught courses (Anderson & Speck, 1998; George & Davis-Wiley, 2000; Rinn & Weir, 1984). Some recommend

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team teaching as a fairly low-cost, yet innovative, method of enhancing instruction. For example, related to the course specifically examined in this research, Rumsey (1999) asserts that team teaching strengthens introductory statistics teachers' sense of professional community and increases the quality of statistics education.

However, empirical analysis of this practice remains scant, particularly over the last two decades. Thus, this study seeks to contribute to a fuller understanding of the efficacy of team teaching as a tool for the improvement of teaching and learning. In so doing, it asks and answers: Is there a statistically significant difference in student comfort with course material, the relationship of course material to work and interest in course material, as well as in academic performance between team-taught and solo-taught sections of research and statistics? Participants include college of education graduate students who self-selected into sections prior to their knowledge of the learning environment (solo versus team).

Literature review

Defining team teaching

Team teaching most often refers to two or more faculty members who jointly produce a course (Davis, 1995). The arrangements vary considerably among teams, and there seems to be little agreement on what constitutes the *team* part of team teaching or even what to call the arrangement—team teaching, coteaching, coenrolment, collaborative teaching, or cooperative teaching (Luckner, 1999). We elect to use the term 'team teaching' in this iteration.

Some define the practice rather generally. Gurman (1989) states: ''Team teaching is an approach in which two or more persons are assigned to the same students at one time for instructional purposes'' (p. 275). Likewise, Easterby-Smith and Olve (1984) write: ''Team teaching involves two or more teachers collaborating over the design or implementation of the same course'' (p. 221).

While others define it more specifically, diversity in the constitution of that definition persists. Davis (1995) categorises the approaches on a continuum. At one end is the serial arrangement in which instructors teach the same course but each takes a block of time. Morlock et al. (1988) describe such a 'rotational' approach in their implementation of an introductory psychology course. While such a division of labour carries with it distinct advantages, Needleman and Leland (1973) characterises this as ''alternate solo performers'' (p. 2) and Pugach, Johnson, and Lilly (1995) believes that such an arrangement violates the intent of team teaching.

At the other end of the continuum are those who plan and implement together. Deighton (1971) describes this 'collaborative' approach as ''two or more teachers [who] regularly and purposefully share responsibility for planning, presentation, and evaluation of lessons prepared for the same group of students'' (p. 89). In this arrangement, the instructors work far more cooperatively throughout the process, from planning to grading, including active participation in all class sessions (Nudelman & Schlosser, 1976; Paul & McAndrews, 1991).

As Anderson and Speck (1998) asserts, and the preceding discussion illustrates, any study of team teaching requires clearly defining the term and its application. For the purposes of this study, team teaching is defined consistently with Deighton (1971) as ''two or more teachers [who] regularly and purposefully share responsibility for

planning, presentation, and evaluation of lessons prepared for the same group of students'' (p. 89). A specific description of the partnership inherent in this study will be provided in the methods section.

Prior research results

Relatively little research literature exists on the topic, perhaps reflecting the sporadic practice of team teaching in higher education (George & Davis-Wiley, 2000). Furthermore, scant empirical evidence has been published on the results of team teaching (Anderson & Speck, 1998), particularly in the last 20 years. Twenty-five years ago, Schustereit (1980) provided a comprehensive review of prior empirical research on team teaching and concluded that research to date had failed to confirm team teaching's critics or supporters.

For example, authors such as Nudelman and Schlosser (1976), Cornett (1970) and Dupuis and Woerdehoff (1967) reported greater levels of student achievement in team taught (experimental) groups as compared to control groups. However, others, such as Bord-Bowman (1973) and Zitelli (1967), reported no significant differences in student achievement between experimental and control groups due to teaching format.

Since Schustereit's review, research on team teaching in higher education has been overwhelmingly descriptive or qualitative in nature, often consisting of reports and reflections of faculty who have participated in such arrangements. Most of these authors discuss positive results and benefits from team teaching. Garner and Thillen (1977), Fu and Chase (1991), Anderson and Speck (1998), Colarulli and McDaniel (1990) and Winn and Messenheimer-Young (1995) emphasise the benefit of multiple perspectives in class, including diverse expertise, the value of diversity and the modelling of collaboration.

Rinn and Weir (1984) discusses how team teaching increases student participation. As teaching partners dialogue in class, students infer the freedom of and value in multiple perspectives, which increases participation and intellectual enthusiasm. Quinn (1984) also highlights how effective team teaching values respect for individuals and ideas, while colleagues interact and discuss substantive issues in the classroom, particularly in the face of intellectual differences or disagreements.

In addition to its effect on students, authors address the implications of team teaching on instructors. The principal theme in those articles is time: ''Team teaching is more time-consuming than teaching alone'' (Davis, 1995, p. 115). Instructors who practice collaborative rather than rotational team teaching meet regularly for course preparation and in-process weekly meetings and debriefing sessions (Hatcher & Hinton, 1996).

Team teaching and learning environments

Although more time consuming, students in team-taught classes often describe the learning environments as 'rich' in knowledge, perspectives and experiences (McKinley, 1996). To begin, when two teachers collaborate in the same setting, a broader array of expertise is brought to bear in the classroom (Hughes & Murwaski, 2001; Jurena & Daniels, 1997). Often, responsibility over course material will be distributed so that one instructor 'takes the lead' on topics over which she or he feels a greater level of expertise, but inevitably both instructors share relevant

perspectives and experiences, thereby creating an environment characterised by greater depth of knowledge.

In fact, those features of collaboration and interaction in particular distinguish the team-taught learning environment from other arrangements (Crow & Smith, 2003; Hughes & Murwaski, 2001; McKinley, 1996). As instructors collaborate and interact in the implementation of the course, students see these behaviours modelled and respond in kind (Jurena & Daniels, 1997). A specific form of interaction, disagreement, can be a particularly powerful example to students, as it models civil and rational debate and discourse. Moreover, disagreement acts as an 'ice-breaker' and facilitates a learning environment that encourages students to enter into civil and rational debate with instructors and with each other (McKinley, 1996).

Indeed, Crow and Smith (2003) asserts that team-taught learning environments take on the spirit and example set by the instructors, so that, if the teachers are amiable, work well together, use and enjoy humour, interact, collaborate and model different perspectives on issues, the environment takes on the same spirit and students assume the same attitudes and approaches to learning. Hecht, Roberts, and Schoon (1996) contend that such results are more likely to occur given the positive effects of team teaching on the teachers themselves. That is, team teaching increases instructor motivation and improves teacher affect, and the class environment therefore assumes the same ethos. Students have likened collegial, interactive, collaborative team-taught environments to that of a family (McKinley, 1996).

Beyond interactions among participants, team teaching often also leads to modifications to the traditional learning environment (Roth, Tobin, & Zimmermann, 2002). Having multiple instructors allows creativity and flexibility in class structure so that teachers can differentiate instruction and learning activities, role-play, simulate conflict, practice Socratic dialogue and so forth (Hughes & Murwaski, 2001). One of the more powerful capabilities is the opportunity to create a more personalised learning environment for students (McKinley, 1996), through individual consultation and attention, that is more responsive to students' needs (Hecht et al., 1996; Richardson, 1993). In addition, students' individual learning styles can be met through inevitable differences in teaching styles (Hughes & Murwaski, 2001; Jurena & Daniels, 1997).

Through the creation of interactive, collaborative and differentiated learning environments, students frequently report greater levels of ease and interest in participating in their learning, which contributes to increased comfort with and understanding of course material (Crow & Smith, 2003; Jurena & Daniels, 1997; McKinley, 1996). Such environments also facilitate constructivist-type classrooms in which teachers model the creation of new knowledge through their interaction, collaboration and debate (Crow & Smith, 2003). Students, thereby, intuit their own ability to create and apply new knowledge through the intersection of their individual perspectives and knowledge with new ones that they encounter in class and elsewhere (McKinley, 1996).

Purpose of the study

Although these conclusions are helpful in understanding the relationship between team teaching, learning environments and student outcomes, the sources out of which the conclusions are drawn are overwhelmingly qualitative in

nature and represent a variety of educational levels—elementary, secondary and post-secondary. What remains missing are empirical studies designed to test the efficacy of team teaching as described by the aforementioned articles and among adult learners, which is our focus of inquiry as teachers of adult learners. Therefore, this article tests some of the conclusions and assertions listed above (specifically comfort, interest, application of course material and student achievement) with a sample of graduate students in different sections of research and statistics.

Methods

This research began by asking the following:

1. Is there a statistically significant difference in graduate student comfort with research and statistics, the perceived relationship of research and statistics to work, and interest in research and statistics between team taught and solo taught sections?
2. Is there a statistically significant difference in student achievement in a research and statistics course between team taught and solo taught sections?

Description of learning environment

Data were collected from three solo-taught sections ($n = 47$) and one team-taught section ($n = 55$) of a three-credit graduate-level introduction to research and statistics class. The course is required of all graduate students in the college of education at a medium-sized, comprehensive, public, regional research university in the USA. The students represent four different departments and several different degree or licensure programs, including teacher education, leadership, counselling and special education. The principal investigators included a female assistant professor of special education, a male assistant professor of educational leadership, and a male lecturer of educational research and statistics. The first two investigators taught in the team format, and each also taught a solo section of the course. The third investigator taught a solo section.

The course, because of its introductory status, assumes that students have not completed such a class or that they took one some years prior (meaning their knowledge and skills are 'rusty'). Thus, the earlier of the 16 course sessions cover library research, databases and writing literature reviews, while later sessions address quantitative and qualitative methods, such as *t*-tests, ANOVA, ethnography, case studies, content analysis and so forth. Course assignments include laboratory work in which students apply lecture topics, research topics, and read and analyse published research.

As noted in the literature review, the team teaching was a collaborative effort from course planning to implementation. Materials, content and schedule were planned collectively in weekly meetings. During implementation, both instructors attended and participated in each class session. Although one instructor would 'take the lead' for a lecture during a given session, the other would actively contribute further information in the lecture, answer student questions, or lead a discussion on assigned readings. The instructors also graded assignments using the same rubrics (which were co-created by the team), grading scales, etc.

Data

The courses were regularly scheduled sections into which students self-selected. While selection bias is always a concern in such cases, self-selection here was not specifically related to the experimental treatment. Students who enrolled in the team-taught section did not know it was team taught until the first day of class, and none of the students in either condition knew of the study prior to enrolling in their respective sections. All students were asked to sign letters of agreement for participation in the study and, while their participation was voluntary, all students provided written consent. Because surveys were completed with assurances of anonymity, achievement tests (on which students wrote their names) were not linked to survey responses.

Survey data

All students completed pre- and post-surveys (see Appendix A for the survey). The survey data consisted of 15 closed-ended questions that used a five-point Likert scale, where 5 indicated Strongly Agree and 1 indicated Strongly Disagree. Students in the team-taught section also completed six open-ended questions at the end of the course. Closed-ended question topics derived from themes prominent in the aforementioned team teaching and learning environments literature. Specifically, we were interested in measuring comfort with and interest in course material, the perceived application of the course to professional work, and the ability to understand course material.

Principal components factor analysis with varimax rotation was performed on the data from closed-ended survey items for both the pretest and posttest. This method of rotation was employed because it enhances the interpretability of the factors (Norussis, 1985). The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used to determine the advisability of proceeding with the factor analysis. For the current study, a KMO sampling adequacy measure was 0.73 for the pretest and 0.72 for the posttest, which are considered acceptable. The Bartlett's test of sphericity value was 241.838 for the pretest and 254.980 for the posttest ($p = 0.000$ for each). Thus, both tests indicate that the survey data are adequate for factor analysis.

To confirm the survey's factors, we applied the Kaiser criterion, also known as the 'eigenvalue-greater-than-1' criterion (Stevens, 2002). Results of the procedure in SPSS gave three common factors with eigenvalues >1.00 for both the pretest and the posttest. The three factors' eigenvalues, the percentage of variances accounted for by each, and the cumulative percentage of variance are presented in Table 1.

Table 1 Eigenvalues, percentage of variance and cumulative percentage of variance for three factors

Factor	Eigenvalue		% of variance		Cumulative % of variance	
	Pre	Post	Pre	Post	Pre	Post
I	3.142	3.439	21.928	22.909	21.928	22.909
II	1.967	1.675	20.433	20.694	42.361	43.603
III	1.116	1.185	19.881	19.389	62.242	62.993

Factor loadings of 0.65 and greater were considered in the interpretation of the factors. The survey items that clustered for each factor on both the pretest and the posttest were the same and confirmed three factors: comfort with research and statistics (pre $\alpha = 0.75$; post $\alpha = 0.72$); perceived relationship of research and statistics to work (pre $\alpha = 0.65$; post $\alpha = 0.68$); and interest in research and statistics (pre $\alpha = 0.70$; post $\alpha = 0.74$). Appendix B includes the factor loadings.

Surveys also were used to collect information about students' sex, age, years of paid experience and degree program (counselling, teacher education, special education and leadership), several of which have been demonstrated as significant in both achievement in and perspectives on the learning environments of research and statistics courses (Fitzgerald & Jurs, 1996; Hong & Karstensson, 2002; Onwuegbuzie, 2000; Onwuegbuzie, Slate, Paterson, Watson, & Schwartz, 2000; Schram, 1996). Table 2 includes frequency of each category for these variables.

Achievement data

Two achievement measures were used. The first was a 25-item test covering introductory-level concepts ranging from the use of research databases to statistical procedures (correlation, *t*-tests, etc.). This measure was used as both a pretest and a posttest enabling us to measure student growth in achievement. The second measure included the students' final grades in the course represented by percentage scores.

Data analysis

Data were analysed using SPSS 14.0. First, pre-achievement test and pre-survey means for the solo-taught and the team-taught sections were tested for homogeneity

Table 2 Frequencies for instructional type, sex, degree program, age and paid experience

Variable	Frequency
1. *Instructional type*	
Single-taught	47
Team-taught	55
2. *Sex*	
Female	69
Male	23
3. *Degree program*	
Counselling	6
Leadership	6
Special education	15
Teacher education	64
4. *Age* (*years*)[a]	
20–25	21
26–35	32
36–45	18
46 and older	20
5. *Paid experience*[b]	
<1 year	45
1–4 years	32
5 or more years	15

[a] For age, $M = 35.45$ and $SD = 10.25$ years

[b] For paid experience, $M = 2.38$ and $SD = 4.10$ years

using independent *t*-tests. Results indicated no statistically significant differences on any pre-measures based on instructional group (solo- versus team-taught). In other words, students in all sections began at basically the same point in terms of knowledge of research and statistics and survey constructs.

Second, pre-post differences for each survey factor and achievement were examined for all students combined using a paired-samples *t*-test. Third, pre-post differences for each survey factor were examined discretely for differences based on teaching format (solo- versus team-taught), while controlling for the aforementioned demographic variables using MANCOVA. Finally, course grades and pre-post differences in achievement were analysed based on teaching format using independent *t*-tests.

Results

Survey factors

Pre-post differences for the three factors from the survey were examined for all students combined. Results indicate a significant increase ($M = 0.59$, $SD = 0.80$), $t(92) = 7.05$, $p = 0.000$, $d = 0.66$) for the comfort with research and statistics factor. No significant differences were found for the remaining two factors. Second, when examining the pre-post difference for each survey factor based on teaching format (team- versus solo-taught) and when controlling for the demographic variables, only the Relationship between Work and Research and Statistics factor proved significantly different ($F = 4.07[1, 89]$, $p = 0.047$, $\eta^2 = 0.047$). Solo-taught students reported a pre-post increase in the perceived relationship between work and course material ($M = 0.24$, $SD = 0.67$), while the team-taught section reported a pre-post decrease ($M = –0.05$, $SD = 0.56$). Finally, the results indicated no statistically significant interactions between any of the opinion factors and the demographic variables.

Achievement

When pre-post achievement changes on the 25-item test for all students were examined, results indicated significant achievement growth ($M = 8.15$, $SD = 3.41$), $t(101) = 24.12$, $p = 0.000$, $d = 2.48$). However, the difference based on teaching format did not prove to be statistically significant (equal variance not assumed). Although nonsignificant, the team-taught section's mean difference was lower ($M = 7.71$, $SD = 2.75$) than the solo-taught section's mean ($M = 8.66$, $SD = 4.02$).

When using final grades as a dependent measure, the difference between team-taught and solo-taught sections was significant ($t[101] = –2.43$, $p = 0.017$, $d = 0.43$) (equal variance assumed). Students in team-taught sections ($M = 0.93$, $SD = 0.035$) obtained higher course grades than those in solo-taught sections ($M = 0.89$, $SD = 0.093$). Also of note are the effect sizes (in standard deviations) for the difference between solo- and team-taught sections on each dependent measure. For both measures, the team-taught distributions exhibit notably less variance than solo-taught sections. Levene's Test of Equality of Variance indicated sample homogeneity in the distributions of grades, but the difference in variance between groups on the achievement test was significantly different ($F = 11.61$, $p = 0.001$).

Discussion

This research investigated differences in student perspectives and achievement between graduate students in a team-taught section versus those in solo-taught sections of a research and statistics course. Like any research, this study had some limitations. First, randomisation was not used. Of course, none of the students knew about the study or even the teaching format before choosing a section, thus avoiding one type of selection bias. But the lack of randomisation still makes external validity tenuous, as do the relatively small sample sizes. Finally, as with any measure of 'success', the use of a single assessment always legitimately raises issues of both validity and reliability.

Nevertheless, the findings are important on several counts. The fact that, on average, students in all of the sections realised significant achievement gains and increased comfort with research and statistics strikes an encouraging note for the instructors/researchers. As we repeatedly tell students in these courses, knowledge of and comfort with research and statistics is increasingly important in contemporary educational environments driven by data. Thus, these overall gains are noteworthy.

However, for team teaching enthusiasts, this study's results remain mixed. Consistent with Bord-Bowman (1973) and Zitelli (1967), graduate students in a team-taught research and statistics course did not demonstrate a significantly greater mean achievement score than those in solo-taught sections when using an achievement test as the measure. In fact, the former students appeared to perform worse. Moreover, only scores on one factor (relationship of research and statistics to work) differed significantly according to teaching format, with team-taught students reporting a lower mean at the course's completion.

The latter difference largely could be a function of sample characteristics. Students in the team-taught section were mainly preservice teachers who had not yet assumed full-time responsibility as teachers. But the solo-taught sections included substantively more working professionals who were pursuing further education. Thus, the latter students could have seen the immediate applicability of course material because of their work circumstances.

While achievement test results were not significantly different for the two groups, final course grades were significantly higher among team-taught students. Also team-taught students' scores on all dependent measures exhibited less variance than did those of solo-taught students. Such results could be evidence of the cumulative effect of team teaching over an entire course. That is, although the achievement test measured one domain of knowledge created in the course, the positive effects of a team-taught learning environment could manifest themselves in other measures included in the final grade.

As Hughes and Murwaski (2001) describe, team-taught environments often involve differentiation of instruction and learning activities; the team-taught course examined in this article was no different. While the course topics and text remained consistent across sections, multiple instructors inevitably allowed a more flexible and creative learning environment. Moreover, as several authors have noted (Hughes & Murwaski, 2001; Jurena & Daniels, 1997; McKinley, 1996), multiple instructors create a 'richer' learning environment, due to multiple perspectives and more effectively catering to individual learning needs. Indeed, when

students were asked in open ended-survey questions to compare this class to solo-taught classes that they have taken, comments (e.g. ''Having two instructors made this class enjoyable'', ''I enjoyed having two perspectives, two ways of teaching the information'') typified students' observations about the team-taught section. In fact, the latter comment received more mention than any other.

Also of note was the lack of significant interaction between the survey factors and any of the demographic variables, particularly given prior research findings. For example, Hong and Karstensson (2002) and Schram (1996) note significant differences in anxiety about or performance in statistics courses based on gender. Likewise, several authors (Fitzgerald & Jurs, 1996; Onwuegbuzie, 2000; Onwuegbuzie et al., 2000) identify age as a significant predictor of anxiety or performance as related to research or statistics classes. Although one might therefore expect differences based on age or gender on at least the pre-survey, none were evident.

In terms of implications, one might consider using results like these to dismiss future discussions of team teaching as a way to improve learning environments, but we caution against this. The mixed results obtained point to the importance of multiple and varied dependent measures to reflect the often multifaceted environments that characterise team-teaching classrooms. Certainly achievement measures such as knowledge tests are important, but they are but one aspect of the student knowledge and learning inherent in any environment. For example, qualitative results from the team-taught course were quite positive, and these results are likely to influence how students view their overall educational experience at the university. Moreover, because the majority of these students complete at least one research class following the introductory course, differences could manifest themselves later in the students' programs. Moreover, statistical significance does not mean practical significance. Indeed, the difference in how students rated the relationship between work and course content could have been statistically significant, but the effect size was quite small ($\eta^2 = 0.047$). However the effect size difference for final grades was moderate ($d = 0.43$). Thus, measuring the importance of these findings, or any findings for that matter, require as broad a consideration as possible.

Additionally, like the students, the instructors found team teaching to be a positive and beneficial experience. Due to important personal and professional differences between the instructors, both gained greater insight into both course content and instructional practices. As students noted and appeared to appreciate, these differences often found their way into the classroom. We know that the results of team teaching for the instructors also manifest themselves in other courses we teach. Thus, the 'professional development' gained through instructional collaboration cost the university essentially nothing, but potentially yielded worthwhile results yet unmeasured. To that end, we believe that further research into the implications of team teaching on learning environments is necessary.

Appendix A

Survey constructed for the study

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. If I read a research report in my discipline, I could apply it to my work.	1	2	3	4	5
2. I am interested in reading research results related to my discipline.	1	2	3	4	5
3. I would consider subscribing to a research journal.	1	2	3	4	5
4. I feel confident in my ability to understand research.	1	2	3	4	5
5. Research and statistics make me anxious.	1	2	3	4	5
6. I could usefully perform research in my work.	1	2	3	4	5
7. I am interested in research and statistics.	1	2	3	4	5
8. This course is an important part of my degree program.	1	2	3	4	5
9. I would take this course even if it was not required.	1	2	3	4	5
10. Research is not as useful as experience.	1	2	3	4	5
11. I feel comfortable distinguishing between well designed and implemented research and poorly designed and implemented research.	1	2	3	4	5
12. I am worried about my grade in this course.	1	2	3	4	5
13. I hope to never deal with research and statistics after the completion of this course.	1	2	3	4	5
14. I believe research can improve my work.	1	2	3	4	5
15. Research findings should influence my work.	1	2	3	4	5

16. Age ___
17. Sex: Female ___ Male ___
18. Degree Program: Counselling ___ Leadership ___ Special Education ___ Teacher Education ___
19. Years of paid experience in your field ___

Appendix B

Items and factor loadings

Item	Factor loading	
	Pre	Post
Comfort with course material		
Q4. I feel confident in my ability to understand research.	0.769	0.752
Q5. Research and statistics make me anxious.	0.830	0.843
Q12. I am worried about my grade in this course.	0.802	0.780
Interest in course material		
Q7. I am interested in research and statistics.	0.702	0.779
Q8. This course is an important part of my degree program.	0.734	0.656
Q9. I would take this course even if it was not required.	0.789	0.829
Relationship of course material to work		
Q14. I believe research can improve my work.	0.874	0.766
Q15 Research findings should influence my work.	0.899	0.865

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