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Co-teaching is a promising and cost-effective approach to promoting fundamental research-based instructional change. In this chapter, we discuss the theoretical underpinnings of co-teaching and describe our initial experience with it. A new instructor (MF) co-taught with an instructor experienced in physics education research-based reforms (CH). An outsider (AB) conducted separate interviews with each instructor and observed several class sessions. Results include immediate use of research-based instructional practices by the new instructor and a significant change in teaching beliefs over time. Recommendations are made for implementing co-teaching as part of a faculty development program.

M ost reforms in college-level teaching call for a significant shift in the role of teachers from content experts who can impart their knowledge to students to facilitators of the learning process (e.g., Barr & Tagg, 1995). The National Research Council's Committee on Undergraduate Science Education calls for undergraduate teaching faculty to "be prepared to use combinations of inquiry-based, problem-solving, information-gathering, and didactic forms of instruction under appropriate classroom circumstances that promote conceptual understanding and students' ability to apply knowledge in new situations" (National Research Council, 2003, p. 27). Research on teaching and student learning has supported the improved learning outcomes of such approaches (e.g., Handelsman et al., 2004), and faculty developers at colleges and universities are key agents in helping faculty learn to teach using such research-based approaches.

Cuban (1999) refers to such a shift in the role of teachers as a fundamental change and distinguishes between fundamental and incremental changes: "*Incremental changes* aim to improve the efficiency and effectiveness of existing structures, cultures, and processes" (p. 63). "*Fundamental changes* are those that aim to alter drastically the core beliefs, behaviors, and structures" (p. 64). This distinction between fundamental and incremental changes is important because fundamental changes always face significant resistance while incremental changes often do not (Elmore, 1996). Thus, it is likely that different faculty development approaches are needed to bring about each type of change.

Obstacles to Fundamental Teaching Change

Research indicates that a major obstacle to faculty development aimed at bringing about fundamental change is that instructors attempting to change traditional practices are acculturated into and surrounded by a culture that reflects their current practices (Ben-Peretz, 1995; Fullan, 2001; Kezar, 2001; Loucks-Horsley, Hewson, Love, & Stiles, 1998). Thus, in order to change, they must undergo a fundamental *internal* change in their views about teaching and learning. Even when instructors are able to successfully make such an internal change, they are typically still immersed in their current situation. Many aspects of this situation likely conflict with their new views of teaching (Kezar, 2001). For example, in an interview study, physics faculty cited strong situational constraints that made it difficult to teach in a nontraditional manner (Dancy & Henderson, 2005). Challenges such as large class sizes, broad content coverage expectations, classroom infrastructure, scheduling constraints, and poor student preparation/motivation all appear to favor traditional instruction.

Students often pose another barrier to teaching change by resisting new instructional strategies (Felder & Brent, 1996). In a traditional science class, for example, students and instructors often abide by a "hidden contract" whereby students are responsible for sitting quietly and asking clarifying questions while teachers are responsible for presenting clear lectures and solving example exercises that are not too different from test questions (Slater, 2003). When an instructor attempts to change this contract, many students feel threatened and resist (Mazur, 1997).

Because of the conflicts with existing cultures (both personal and institutional), new instruction that calls for research-based fundamental changes (e.g., transforming classrooms from passive to active learning) is often altered by instructors and implemented as incremental changes. Although such implementation may keep some of the surface features of the innovation, it is essentially traditional instruction. For example, research suggests that

instructors may attempt to implement the peer instruction strategy (Mazur, 1997), but without the peer interaction component (Henderson, 2005; Henderson & Dancy, 2005). Henderson and Dancy (2005) developed the term *inappropriate assimilation* to describe this type of "adoption." Innovations requiring fundamental changes appear to be quite susceptible to inappropriate assimilation (Boyer Commission on Educating Undergraduates in the Research University, 1998; Hutchinson & Huberman, 1993; Spillane, 2004; Stigler & Hiebert, 1999; Yerrick, Parke, & Nugent, 1997).

Common methods of faculty development to promote teaching change include talks, papers, and workshops aimed at convincing individual faculty to change their instruction and giving them information and materials in support of a specific research-based strategy. For instructors to fundamentally change their instruction, however, they must simultaneously transform their personal views about teaching and learning to align with the new instruction as well as use this understanding to adapt the new instruction to their unique situation. Such fundamental change requires more support than these typical faculty development approaches provide (Cox, 2001, 2004; Rice, Sorcinelli, & Austin, 2000).

An additional barrier to standard workshop-based faculty development approaches in promoting fundamental teaching change is the complex nature of teaching itself. Similar to any complex task, much of a teacher's decision-making is implicit (Berliner, 1987; Mitchell & Marland, 1989). It would be an overwhelming task for a faculty developer to make all of the implicit decisions explicit and equally overwhelming for an instructor to attempt to externalize these decisions. The ability to make "correct" decisions implicitly is learned through experience and reflection (Berliner, 1987; Schön, 1983; Van Driel, Verloop, Van Werven, & Dekkers, 1997; Wilson, Shulman, & Richert, 1987).

Establishment of Teaching Styles by New Faculty

Many new faculty, particularly in the sciences, have held teaching assistant (TA) appointments in graduate school. However, relatively few have actually taught a course of their own before their first faculty position. Thus, these first years of teaching are a formative time in the development of an instructor's teaching style and likely an ideal time for interventions aimed at promoting nontraditional instructional practices (Saroyan & Amundsen, 2004).

However, for new faculty on the tenure track, any departure from traditional instruction may be dangerous because such changes may require more time than traditional instruction and result in lower student ratings, especially at first (Seymour, 2001). Studies of new faculty show that it is quite common for them to spend a majority of their time on instructional activities and to receive

poor student ratings under normal conditions. Boice (1991) studied 77 new tenure-track faculty at two different universities (one with a research emphasis and one with a teaching emphasis) via interviews and observations. By the middle of their first semester, most of the new faculty complained about the lack of collegial support and reported that lecture preparation dominated their time. Few of the faculty reported teaching skill as depending on anything other than their knowledge of content and clear, enthusiastic presentation. Most described their classes as standard facts-and-principles lecturing and many had no plans for improving their teaching. Boice concludes that new faculty typically teach cautiously and defensively and tend to blame low student ratings on external factors (e.g., poor students, heavy teaching loads, and invalid rating systems). He suggests that new faculty would benefit from programs that helped them find ways to increase student participation and avoid overpreparing facts.

Thus, because new faculty already struggle with learning how to teach, this is the time to assist them in developing a research-based instructional style. Instructional change in new faculty still involves fundamental change because these new faculty were likely involved largely in traditional teaching approaches as students and TAs. We propose co-teaching as one model for promoting such change in new faculty.

What Is Co-Teaching?

The practice of co-teaching was developed by Roth and Tobin as an alternative to the standard student teaching practice associated with most K–12 teacher preparation programs (Roth, Masciotra, & Boyd, 1999; Roth & Tobin, 2002). In standard student teaching, the student teacher typically first observes several of the master teacher's classes, then the student teacher takes over the class on his or her own. Roth argues that student teachers do not often develop the tacit knowledge necessary to be good teachers under this arrangement (Roth et al., 1999). During co-teaching, on the other hand, the student teacher and master teacher share responsibility for all parts of the class. Student teachers "begin to develop a feel for what is right and what causes us to do what we do at the right moment" (Roth et al., 1999, p. 774).

Co-teaching is consistent with a cognitive apprenticeship paradigm of instruction, in which

> novices and experts are from different worlds, and a novice gets to be
> an expert through the mechanism of acculturation into the world of
> the expert. Actual participation in this world is critical for two rea-
> sons: (a) much of the knowledge that the expert transmits to the

novice is tacit, and (b) the knowledge often varies with context. (Farnham-Diggory, 1994, p. 466)

Co-teaching differs from team teaching in intention (acculturation to teaching vs. interdisciplinary connections), process (cognitive apprenticeship vs. collaboration), and intended outcome (aimed at teaching change primarily and student learning as a secondary vs. student learning primarily) (e.g., Austin & Baldwin, 1991; Erby, 2001). Although we are aware that co-teaching activities have occurred at the college level at other institutions, scant research (Eddy & Mitchell, 2006) has identified its uses, costs, and benefits or documented the results of this approach to fostering fundamental teaching change.

Data Collection and Analysis

The goal of this study was to develop a better understanding of the prospects of co-teaching for promoting fundamental instructional change through the in-depth investigation of one co-teaching experience. This is what Stake (1998) refers to as an instrumental case study. The expectation is that a deep understanding of this single case can be used to provide insight into the use of co-teaching in other similar settings.

The Case

The case under investigation was the fall 2005 co-teaching of the first semester introductory calculus-based physics course at Western Michigan University (WMU) by two of the authors, CH and MF. CH was an experienced instructor in his fourth year of teaching at WMU. He had been involved in the research-based reform of the introductory calculus-based physics sequence at WMU and had previously taught both of the courses in that sequence using reformed methods. He was also an experienced physics education research (PER) researcher with knowledge about many PER instructional interventions. MF was a new tenure-track faculty member in his first semester at WMU. All of his prior teaching experience was as a physics TA while a graduate student at the Ohio State University (OSU). As a graduate student at OSU he had some exposure to PER via his interactions with the OSU physics education research group, which ran a required quarter-long course for TAs. The purpose of co-teaching was to allow MF to gain enough experience with the WMU reforms that he would implement a fundamentally reformed course in subsequent semesters. He was scheduled to teach the same course on his own in spring 2006.

From a cognitive apprenticeship perspective, the goal of co-teaching in the current study was to acculturate MF into research-based physics instruction as

embodied in the design principles developed and enacted by the WMU reformers. As discussed earlier, the largely tacit and context-dependent nature of teacher decision-making means that learning to teach in a reform-compatible manner requires more than just talking about teaching; it requires *direct experience* in the practice of teaching. This is especially true because the culture—that is, the assumptions and norms—of reformed teaching is very different from the culture of traditional teaching.

The co-teaching took place in the lecture portion of an introductory calculus-based physics course at WMU. The four-credit course (Phys 2050: Mechanics and Heat) met each weekday for 50 minutes and enrolled about 70 students, mostly engineering majors, in a stadium-style lecture hall with fixed seating. CH and MF were both listed as the instructor of record for the course. There were five basic co-teaching activities. Each of these is described briefly next, then considered from the perspective of a cognitive apprentice instructional framework.

CH and MF alternate being in charge of class each week. Although both of the instructors were present during each class session, they alternated being "in charge" of the class on a weekly basis. The person in charge typically presided over any whole class discussions or presentations. Students spent much of the class working in assigned small groups, during which both instructors circulated around the lecture hall and interacted with the groups. The instructor in charge developed the first draft of the weekly quizzes or exams and shared them with the other instructor for comment.

CH and MF held weekly meetings to reflect on the previous week and discuss initial plans for the coming week. Each Friday, CH and MF met for approximately one hour, during which they talked about how things went the past week and any difficulties that arose. The instructor in charge of the following week then presented his initial plans for discussion. In addition, CH and MF frequently discussed the course more briefly at other times.

CH set up the course structure to reflect design principles supported by educational research. CH based the course structure on his previous successful teaching of the course, reserving much of the class time for students to work together and discuss physics concepts in small groups.

MF had access to materials used by CH in previous offerings of the course. At the beginning of the semester, CH provided MF with electronic copies of all the course activities and assignments used in the previous semester. MF typically used, with minor modifications, about half of these and developed the other half himself.

MF taught the course on his own during the subsequent semester (spring 2006).

Table 13.1 shows how each of the co-teaching activities match with the cognitive apprenticeship instructional model (Collins, Brown, & Holum, 1991). There are six basic aspects of this approach:

- Modeling, in which an expert performs a task so the novice can observe

- Coaching, when an expert observes and facilitates while the novice performs the task

- Scaffolding, in which the expert provides support to help the novice perform the task

- Articulation, when the expert encourages the novice to verbalize his or her knowledge and thinking

- Reflection, when the expert enables the novice to compare his performance with others

- Exploration, when the expert invites the novice to perform additional tasks with decreasing support

These aspects are not linear; they can be woven into multiple activities and are assumed to be iterative, repeating as needed as the novice gains skill and confidence.

TABLE 13.1

Alignment of Co-Teaching Activities
Within the Cognitive Apprenticeship Framework

	Modeling	Coaching	Scaffolding	Articulation	Reflection	Exploration
CH and MF alternate being in charge of class each week.	X	X				X
Weekly meetings between CH and MF to reflect on previous week and discuss initial plans for coming week.	X	X		X	X	
Course structure set up by CH to support design principles suggested by educational research.			X			
MF had access to materials used by CH in previous offerings of the course.			X			
MF teaches the course on his own during the subsequent semester.						X

Data Sources

Case study research relies on multiple sources of evidence (Yin, 2003). A faculty member from the college of education (AB) participated in the co-teaching experience as an outsider. She conducted open-ended individual interviews with CH and MF at the beginning, middle, and end of the co-teaching semester. Her interviews focused on the progress of the course, general beliefs about teaching and learning, and the value of the co-teaching. Her final interview was with MF at the end of spring 2006 after he had taught the course on his own. The associated data sources were the interview transcripts of the seven 45- to 75-minute interviews. In addition, AB observed both CH and MF teaching at the beginning, middle, and end of the co-teaching semester. The associated data source was approximately four pages of handwritten field notes taken during each of the six observations following the Reformed Teaching Observation Protocol (RTOP) (Piburn & Sawada, 2000). The final data source was the syllabi used by CH and MF in fall 2005 for co-teaching and by MF in spring 2006 when teaching alone, supported by their own comments on the course structure for each semester.

Data Analysis

Both AB and CH independently analyzed all of the data sources looking for four things: 1) evidence related to MF's instructional practices; 2) evidence related to MF's beliefs about teaching and learning; 3) evidence related to MF's intentions toward future instruction; and 4) any other evidence related to co-teaching that seemed helpful in understanding the experience. After completing this independent analysis, CH and AB compared notes. Their analyses largely concurred and they resolved any differences through discussion. Although not directly involved in the data analysis, MF reviewed and commented on AB's and CH's findings. Therefore, we reached a consensus on all the results reported here.

Results

Our goal was to document changes, if any, and the degree of agreement with the WMU reform principles in MF's teaching practices, beliefs about teaching and learning, and intentions toward future instruction. We examine each of these aspects next.

Teaching Practices

MF and CH received similar scores on the RTOP instrument for each class session as well as similar scores to one another. This suggests that they were both working appropriately within the interactive class structure. AB did notice some more subtle differences, however. For example, in her first observation of MF, she wrote in her field notes, "MF was somewhat more structured than I saw CH to be, but very interactive with students nonetheless. MF presented concepts and then problems that exemplified them. Less of having students generate concepts. More formulas." MF also noticed this small difference:

> I noticed CH's technique [for managing class discussions] is even slightly different from mine.... I am not criticizing him at all because this is his technique and it obviously works, but from my point of view, he doesn't mind letting the students hang for a long time and squirm and sweat over this problem. He will ask some, what I consider, very open-ended questions, whereas I will tend to ask something that I consider slightly more leading.

AB did not note any changes in MF's instructional practices during the semester. These observations suggest that the scaffolding provided by the course structure was effective, right from the start, in helping MF teach in a nontraditional way.

MF perceived a shift in his own instruction toward more focus on concepts and less on mathematics.

> As the semester wore on ... I ended up getting in the habit of ... going through the concepts, setting up the problem, and saying to the students, "You go figure out the algebra on your own." That allows you to go through many more problems, and it also allows you to spend a larger percentage of time on the physics per problem so that they realize that the problem isn't a massive algebraic equation, but it really is physics.

Without this structure it is likely that MF, much like the new faculty interviewed in Boice's (1991) study, would have put much more emphasis on facts-and-principles lecturing. MF confirmed this during the first interview (conducted during the first week of classes when MF had participated while CH was in charge of the class, but had not yet been in charge himself).

> AB: If you were doing this by yourself, if they just said, "Okay, here is your class schedule for the semester. Good luck." What would you be doing? How would you approach preparing for a class like that?

> MF: I would probably not actually in all honesty . . . not have done it the same way that we are treating this class. . . . I [would] probably treat it more like a lecture. Of course I tend to be more interactive, so I will still be more interactive, asking the students questions and things. I probably wouldn't do as many in-class activities as we are doing now . . . and so it will probably be a little bit more like the formal lecture.

MF reiterated this thought in response to a similar question during the final interview with MF after the end of spring 2006. His belief that he would not have taught the course in a reformed manner without the co-teaching approach was consistent throughout all interviews.

Beliefs About Teaching and Learning

Although his beliefs about student learning were consistent throughout the semester, MF's beliefs about teaching appeared to change. He envisioned his teaching as being more interactive than a traditional lecture, utilizing the Socratic method to get students involved in answering questions. However, he was initially concerned about the reformed course structure, in which almost all class time is devoted to group-based problem solving, as too much of a departure from the lecture method.

> I have really come to appreciate the use of in-class problems. It's surprising to know, because when I first came I was skeptical about having students do nothing but problems in class—just sort of standing by while they do problems. It really seems to be a good method.

MF's largest initial concern appeared to be student resistance to such an interactive class structure. Thus, he did not envision such methods being successful until he experienced the students being engaged and was also convinced by a survey of student perceptions of what helped them learn.

> What convinced me about this [the reformed course structure] was that most of the students . . . were really engaged . . . but even more than that at the end of the semester when we gave them the survey, the thing they liked the most was the in-class work. Very strangely surprisingly to me was that they liked doing this and found it to be very helpful to them.

This concern for student opinion was a theme that ran throughout all of the interviews and is consistent with Boice's (1991) finding that new faculty tend to "teach defensively, so as to avoid public failures at teaching" (p. 170).

Intentions Toward Future Instruction

Not surprisingly, as MF's beliefs about teaching changed, his intentions toward future instruction also began to change. From the first three interviews, it appeared that his intentions toward future instruction, specifically the following semester, were changing to become more aligned with a reformed course. By the midterm interview, MF was beginning to become comfortable with the course design but was still largely noncommittal about how these might fit into his future instruction. "You know, it [the co-teaching experience] taught me something that I am going to adopt aspects of in future courses." By the end of the term, though, he seemed to have shifted his perception to be very favorable toward the course structure. "My class [next semester] is going to be very similar to what we did last semester, even the structure will be the same structure. It's going to be almost identical."

Changes MF made to the course after the co-teaching semester and his assessment of those changes revealed lasting change in his teaching beliefs. Even though at the end of the fall co-teaching experience, MF indicated that his spring 2006 course would be "almost identical" to the co-taught course, he later decided to make some changes to the course structure. The spring 2006 course was well within the reformed course structure, but he did pull the course toward a more traditional structure. In addition, he made almost all of these changes to reduce his preparation time or perceived student dissatisfaction. In the final interview at the end of the spring 2006 semester, MF was unhappy with many of the changes that he made and planned to go back to a course structure more closely aligned to the fall 2005 course. He indicated that his direct experience with co-teaching followed by teaching alone convinced him that the course elements were important enough in promoting student learning that they were worth extra time and possible student dissatisfaction.

> I did not do quiz corrections this year, simply because of time constraints involved, and, looking back on that, I think that was a bad idea.... I think students looked at quizzes as sort of a module of the course and once you are done with the quiz you are done with learning that material.... I'm going to readopt those [quiz corrections and group homework] and, it's going to be extra time involved, but in my mind it's worth it.

Other Observed Outcomes

An unexpected yet valuable outcome of co-teaching was that informal discussions helped MF become acculturated to WMU in areas other than teaching.

> I would ask him [CH] everything, not just about teaching. . . . He was actually very helpful in a lot of areas including grant writing. . . . These discussions often sprang from side conversations during the first five minutes before class while waiting for people to mingle in the class.

As Boice (1991) and others (Cox, 2001; Rice et al., 2000) have noted, this additional support is frequently lacking for new faculty.

MF attributed some of his and CH's success with co-teaching to the kind of relationship CH built with him. It was collegial, rather than a student-teacher or mentor-mentee type of relationship.

> Well, the thing that I liked the most about this is it wasn't like I was Charles' protégé. He recognized me as a colleague and we were teaching this class together. . . . It wasn't like teacher-apprenticeship, which at this level might seem sort of insulting.

This collegial relationship differs from the K–12 model of co-teaching, in which the expert/novice differences are more explicit.

Discussion

We believe that there were three important components to the co-teaching design that made it successful: 1) it lasted an entire semester, 2) the course structure was set up in advance by the experienced instructor, and 3) there was a collegial, cooperative relationship between the co-teaching partners. Co-teaching changed MF's teaching beliefs and intentions consistent with the design principles of the reformed introductory physics courses at WMU. The predetermined course structure set up by CH allowed MF to adopt new (to him) teaching practices from the beginning of the semester. MF's beliefs about teaching and learning were largely aligned with the reform principles by the middle of the semester, while his plans for future teaching continued to change throughout the semester and ended compatible with the reforms. Thus, it appears the entire co-teaching semester was important. To just co-teach for the first half of the semester, for example, probably would not have been enough to complete the change.

The Benefits of Co-Teaching for New Faculty

As described earlier, new instructors are typically risk-averse and afraid of making mistakes in their teaching. Thus, any departure from traditional instruction must be made as risk-free as possible, in terms of both student satisfaction and time demands. Co-teaching, as enacted in this project, did this in two ways. First, it allowed the experienced instructor to set up a course structure that was known to work in the particular context, as well as to model and coach the new instructor within the context. Within this structure, the new instructor enjoyed a safe, low-risk setting to practice new ways of interacting in the classroom. In addition, since both instructors were listed as the instructor of record, neither could be held fully responsible for any negative student evaluations (although in this case evaluations were quite positive). The new instructor also saved precious time drawing on previously used materials and only having to do so for half of the classes. He then had more time and energy for the more reflective aspects of co-teaching. In addition, when teaching on his own the following semester, his co-teaching experience and the resources CH provided made it easier for him to continue teaching in the reformed manner than to fall back on the traditional manner and gave him an "ideal" baseline to which to compare his independent teaching.

The Cost of Co-Teaching

In the co-teaching model described here, the only cost is replacing an instructor for one class. In this case, the department hired an adjunct using external grant money. The recommended part-time rate for a four-credit class at WMU in fall 2005 was $2,800, a rate comparable to the national average for part-time faculty (Thornton, 2006). Departments that can absorb an extra class for one semester entail no cost at all. In comparison, Marder, McCullough, and Perakis (2001) calculated the cost of National Science Foundation–funded faculty development workshops (as an example of a common faculty development model) to be $4,200 per participant and found that only 40% of participants reported making moderate or greater changes to their teaching approaches. Institutions can run workshops on a cheaper scale, but the comparison demonstrates that co-teaching offers greater outcomes for less expenditure than other approaches.

Implementation Strategies for Faculty Development

The results of the co-teaching project reported here suggest that co-teaching can be a useful component of faculty development programs. Program directors

can integrate co-teaching into their programming in various ways and play different roles in promoting and supporting it.

For example, co-teaching can be offered as an intensive new faculty development opportunity, with experienced faculty who have been recognized for their teaching excellence serving as ideal co-teaching partners. Co-teaching can also be used to build departmental capacity for research-based teaching approaches. In this case, a chair recruits multiple co-teaching pairs to promote fundamental teaching change across the unit. Finally, co-teaching can be incorporated into other faculty development approaches that support fundamental change, such as faculty learning communities (Cox, 2001, 2004) of co-teaching partners.

Faculty developers play a key role in the success of co-teaching. They can function as coaches and role models in the co-teaching relationship, helping faculty negotiate the details of their co-teaching plan and serving as a soundboard for their reflection. They can encourage both experienced and new faculty members to reflect on their teaching and their work together and to make explicit all of the implicit decision-making they do as teachers. Developers can also serve as research partners, just as AB did in this study, to create a scholarship of teaching and learning project that examines the process and outcomes of the co-teaching relationship.

Further Research

This study was of a single case. More examples of similar cases are needed to build a solid empirical foundation for co-teaching. We also need examples of disparate cases. For instance, how would co-teaching work for other populations, such as an experienced faculty member with an established traditional teaching routine? Would it help graduate students develop teaching expertise (Eddy & Mitchell, 2006)? Perhaps the success of the co-teaching experience depends on elements not identified here. Planning co-teaching experiences for research as well as faculty development can answer such questions.

Conclusion

Co-teaching is a cost-effective model that shows significant promise as an effective way to promote research-consistent instruction in new faculty. It seems to promote more change for much less money than the standard workshop model of faculty development because it immerses new faculty in their new instructional context and provides scaffolding and modeling to ensure success. Of course, co-teaching is only appropriate when a senior instructor

knows how to teach the target course in a research-consistent manner. But with this key element in place, co-teaching can promote fundamental and lasting teaching change while supporting new faculty.

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