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Capstone Course: A Qualitative View into Instructor's Role and Teaching Practices

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Abstract

Capstone courses provide an opportunity for preservice teachers to synthesize their undergraduate learning. Faculty utilize capstone environment to facilitate students successful transition from higher education into the school environment by providing opportunity to reflect and practice students' accumulated knowledge while providing individualized support. Faculty use the capstone environment to help preservice teachers elicit, reflect, and interpret their own understanding of mathematics and to relate it to the secondary mathematics content. This article presents the findings from a series of semi-structured interviews with capstone instructors. Our goal is to entice a conversation related to role of capstone within teacher education programs.

Keywords: mathematics capstone, mathematics faculty perspective, instructional practices, instructor role, teacher education

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Introduction

A capstone course in math education programs serves to prepare preservice mathematics teachers (PSMT) to become successful practitioners in the field. Among undergraduate courses, capstone courses are, the most unique by their nature, objectives, and purpose. They are designed to serve as a bridging tool for preservice teachers' transition into their first career as in-service teachers. Conference Board of Mathematical Science (CBMS, 2001) has emphasized the importance of capstone courses for secondary PSMT not only for the integration of knowledge, but also for the development of necessary connections of the university mathematics and high schools mathematics. It is important for the preservice teachers (PST) to have the opportunity to experience and integrate their content knowledge and pedagogical knowledge to become effective teachers (Hill, Rowan, & Ball, 2005).

During the past few decades, there have been a push for mathematics teacher education programs to provide opportunities for PSMTs to make explicit connections between higher level mathematics topic and mathematics that they will be responsible for teaching in high schools (Artzt, Sultan, Curcio, & Gurl, 2011). CBMS (2001; 2012) recommended that institutions provide adequate opportunity for teachers to develop an in-depth understanding of mathematics and its teaching. Yet, there are no consistency on goals, approaches, and assessment of capstone courses offered across U.S. (Cox et al., 2013). Cox et al., (2013) study of mathematics teacher education programs in the United States has revealed that while capstone courses are not offered at all post-secondary mathematics education programs, many programs see the value of the capstone and continue to offer the course. While, there is little research on understanding capstone instructor's practice and approach, a common practice among researchers is to select a single capstone lesson and provide a case-based study (Gifford, Cannon, Stedman, & Telg, 2011).

The purpose of this exploratory case study is to understand instructional practices of capstone course instructors within mathematics education program across diverse institutional classifications. We explored the design and curriculum of the capstone courses practiced in mathematics teacher education programs, which will be narrated through the capstone instructors. The main drive behind this exploratory study was our discontent with the paucity of research on the topic. Additionally, our goal was to start a conversation among mathematics teacher educators (MTEs) on the role and position of such courses within mathematics education. To start a conversation, we first need to investigate the existing instructional perspectives, in other words provide an inside view of how current MTEs view their role as capstone instructors. The primary research questions for this study are;

1. Role: How do faculty view their role as capstone instructors?
2. Instructions: What are the capstone instructors' instructional practices?

Conceptual Framework: Capstone course in higher education

There is no collective guideline for what a capstone course should look like. It is highly dependent upon the nature of institution. Each program designs their capstone course in accordance with the goal and nature of their program. Applied fields of studies such as education, nursing, engineering, and business, often include a practicum where students

are provided with the opportunity to apply their knowledge within a real work environment (e.g., Butler & Hardin-Pierce, 2005). In such fields, capstone courses are designed to help students transition from students to professionals.

We conducted a literature review on capstone courses that are offered within undergraduate programs across disciplines. That way, we were able to identify the unique features of teacher education capstone courses. What is common across programs is that capstone courses are characterized as past and future-oriented: 1) an endpoint of the prior learning culminating the previous course works and 2) preparing students for their future careers. The existing literature shows that capstone courses across disciplines include the components such as culminating the learning, field experience, and transition to work. We will use these three constructs as a conceptual framework, in order to contextualize the teacher education capstone courses.

1. Culminating the Program. A capstone course, also referred to as senior seminar, is past-oriented in terms of the content. Instead of learning new concepts, capstone courses provide an opportunity for the students to synthesize and integrate concepts previously learned (Davies, 2007). Therefore, most capstone courses do not have a required textbook or teacher-directed instructions, rather students engage in inquiry or research around their own interests. Hauhart and Grahe's (2012) survey on multi-institution capstone courses found that that instructors, often, base their pedagogy on inquiry-guided learning, requiring a substantive literature review or a major research paper. In social science, a capstone research paper is not only used for synthesizing previous learning, it is also used for assessing competency skills (Fernandez, 2006).

2. Merging Theory with Practice. As Lattuca and Stark (2011) explained, practice oriented fields such as engineering, teaching, and nursing offer the capstone as a culminating course during the last year of the program to ensure the prior mastery of the discipline—in the case of teaching, the prior learning mastery includes a mastery of teaching competency. These fields often emphasize the need for field experience during the course (Lattuca, & Stark, 2011). It's not just practice-oriented discipline that incorporate field experience, but humanities and social sciences also actively adopt the idea of theory-practice balance. Though not common, social sciences sometimes incorporate social responsibility and community engagement as part of their capstone project. For example, women's studies and Honors programs actively adopt this idea to provide an opportunity for their students to tackle real world problems and experience a client-based interaction (Reifenberg & Long, 2017).

3. Transition to work. Vosen (2007) described the nature of capstone course as job preparation where the required assignments include research a company, preparing cover letter, and contacting HR manager. Transition to work means transition from university classroom to practice as well as a transition in professional identity, from students to practitioners. Similar to engineering students (Jorgensen, Mescher, & Fridley, 2001), in teacher education, students have an opportunity to learn from the field supervisors and their supervising teachers. A successful transition requires learning the norm of the profession in the real world. In other words, transition to teaching profession includes learning the norm of K-12. Capstone courses provide the bridge between university and the field to ease this transition, to help PST get a feel for what it is like to be an in-service teacher.

Teacher Education Capstone. For the purpose of this article, we define a capstone course as a course that is offered at the final year of the pre-service secondary mathematics teachers' program of study and its primary focus is on accomplishing one or more of the following: (1) connecting upper-level mathematics courses, (2) relating to high school mathematics, (3) providing supplementary exposure to math content that the students may have difficulty with, and/or (4) developing skills in communicating with and about mathematics (Loe & Rezak, 2006).

Drawing on the above three concepts of capstone, we contextualized this study. Our goal is not, necessarily, to compare teacher education capstones with other disciplines, but to gain a better understanding of how mathematics teacher training programs utilize capstone to better prepare PSTs. Conference Board of the Mathematical Sciences (CBMS, 2001) recommends that every prospective high school mathematics teachers complete their undergraduate major with a 6-hour capstone course connecting mathematics course works with high school. Capstone curriculum frequently requires a project that entails an integration of knowledge and skills gained in earlier course works. Not only these capstone projects serves as an integration of content knowledge and pedagogical content knowledge, but also for the development of a variety of professional skills, such as verbal and written communication skills, as such capstone project require written and oral presentation of the final project (CBMS, 2001).

Method

The data for this case study are derived from in-depth interviews with eight faculty members who teach the mathematics capstone courses with single or dual appointments with mathematics or mathematics education departments (Table 1). We recruited capstone instructors from eight universities with different Carnegie classifications, ranking ranging from “Doctoral Universities: Highest Research Activity (R1)” to “Baccalaureate Colleges: Arts & Sciences Focus”.

To identify potential participants, we used College Navigator search engine. College Navigator is a tool designed to provide information including programs offered, size, Carnegie classification, and accreditation about more than 7,000 postsecondary institutions in the United States. College Navigator is a tool—developed by the Integrated Postsecondary Education Data System (IPEDS)—for parents and students to learn about programs and rankings of the universities across the United States (additional information can be accessed from <https://nces.ed.gov/collegenavigator/?cx=1>). To select faculty members who teach senior level courses in mathematics teacher education program, we first had to identify institutions with Mathematics Education majors. We contacted the department heads, explained the research purpose with a copy of the consent, and solicited participation. The department heads solicited voluntary participation from their faculty for us. We had no personal relationship with any of the participants and their institutions.

A 60 minutes long semi-structured interviews were conducted, recorded, and transcribed verbatim. The interviews focus on the instructor's experience with teaching capstone courses, their instructional goals and assessment, their course curriculum, and the challenges they face teaching such a course. All participating instructors have a degree in either math education or mathematics (Table 1). It is also important to note that among the institutions there was a diversity in terms of their teacher education

course requirements, which was not related to the size or their Carnegie ranking. For example, among the participating institutions, some required their PSTs to major in mathematics while enrolling in a secondary education as their minor, whereas enrolling in a teacher education program was sufficient for other programs. Consequently, there is a diversity as in where the capstone course was offered, in a mathematics or education department. Regardless of the location these courses were offered, they were primarily taught by mathematics teacher educators. Additionally, programs that incorporated field experiences as part of their capstone requirements, were more likely to incorporate self-reflection assignment as part of their assessment.

Table 1. Participants 'Demographics

Participant	Area of Terminal Degree	Teaching Capstone Experience	K-12 Teaching Experience	Higher Teaching Experience	Ed.Department	Carnegie Classification of School	Site
Bob	Math	5 years	Yes	5	Math Ed	Baccalaureate Colleges: Diverse Fields	Southwest
Alex	Math Ed	6	Yes	12	Math	Doctoral Universities: Higher Research Activity (R2)	Midwest
Arthur	Math	12	No	14	Math Ed	Doctoral Universities: Higher Research Activity (R1)	Northeast
Don	Math Ed	12	Yes	12	Math	Baccalaureate Colleges: Diverse Fields	Northeast
Linda	Math Ed	1	Yes	7	Math	Baccalaureate Colleges: Arts & Sciences Focus	Northeast
Sherry	Math Ed	4	Yes	5	Math Ed	Baccalaureate Colleges: Diverse Fields	Southeast
Rebecca	Math Ed	2		2	Math	Baccalaureate Colleges: Diverse Fields	Midwest
Eric	Math	5	Yes	5	Math	Doctoral University-Higher Research Activity (R2)	Southwest

Findings

The following sections will be an elaboration of the findings and is organized according to the following questions, (a) what are the capstone instructors' instructional practices?, (b) how do they view their role in relation to effective teaching? All interviews were analyzed with open thematic coding approach to identify common themes. However, we realized that it was important to select and use multiple mediums

to understand MTEs instructional approaches. For that reason, we collected course artifacts such as course descriptions, syllabi, homework assignments, and project descriptions to further understand how the faculty place capstone courses within secondary mathematics programs and what role capstone courses play in furthering PSTs education. Once the codes were recognized, first, we identified the common themes across the instructors within our conceptualized framework. Then, we sorted the data into emergent categories to highlight varying practices. Third, each participating instructor's practice was situated within their syllabus, assignments, their respective institution's course description, curriculum sequence, and structure. This approach yielded four emergent themes of: (1) merging practice and theory, (2) culminating prior learning, (3) transition to work, and (4) reflective thinking

Theme 1: Merging Practice and Theory

The analysis of the interviews and the participating faculty course materials revealed that the participating instructors place heavy emphasis on enhancing teaching skills among PSTs, what Hill et al. (2005) names "mathematical knowledge for teaching" or pedagogical content knowledge PCK (Ball, 1991; Schulman 1986; 1987). The common theme among the participating faculty was that knowing mathematics does not always guarantee knowing how to teach.

Central to pedagogical content knowledge (PCK) is the ability to meet the needs of diverse learners. Often the prospective teachers were required to demonstrate their knowledge of diverse representations of the same mathematics problem to enhance students understanding of mathematics and mathematical process. This belief is aligned with Hill et al. (2008) claim that mathematics teachers need to have the knowledge of incorporating pictures or diagrams to help students understand mathematics concepts and procedures. One participant mentioned, "I think the problem is that they know how to do the problems, but they really don't know how to explain it." For this purpose, some of the participating faculty required writing a lesson plan or teaching demonstration as a part of their final project. Rebecca explained, "Students are asked to prepare a lesson, and they teach a portion of that lesson to their peers to receive immediate feedback followed by a delayed feedback from the instructor." Eric expressed a similar viewpoint:

I have gone to public school teachers and said, you know, which ones are the topic that you view the most difficult in trying to get it across to your students, and so that's where I come up with my list. And basically it's things like word problems, factoring, distribution equations, it's pretty much the same topics from year to year.

Instructors with an added focus on PCK were more inclined to frame their assignments around creating and presenting mathematics lesson plans on a specific mathematics topic. Eric mentioned that "this semester they are doing 15 minute presentations on a particular topic...maybe solving quadratic equations, linear equations, word problems, things of that nature." Rebecca asks her students to critique videos of teachers teaching and critique mathematical dialogue from the classroom discussions.

To practice PCK Alex assigns mock-teaching as a course requirement, followed by a class discussion about different approaches to teach a certain math concept. He explained, "if you hand them the bike and expect them to ride it's not going to work."

They have to be able to try it, make mistakes,...Put whatever they are learning from the textbook into practice, and then get corrected.” Alex explained that a capstone course is the place to learn “how to be able to teach, not so much what to teach, but how to be able to communicate that to the appropriate audience, high school students.”

Theme 2: Culminating Prior Learning

In Teacher Education programs, culminating exercise means integrate theory and practice. For example, Rebecca’s capstone course was designed to provide the opportunity for practicing what PSTs have learned in their theoretical and method courses. As she puts, “capstone is like putting every ingredient together. Let’s bake a cake”. Eric, another participant, mentioned that the capstone is “like the finishing touches on what has occurred before.” For PSMTs, culminating their prior learning occurs when they are able to (a) connect undergraduate mathematics to the teaching of high school mathematics and (b) teach the high school mathematics with relevant pedagogical content knowledge.

Similar to any other content area, the knowledge of the mathematics content is the primary concern for PSMTs as Winsor (2009) stated, it is impossible to teach mathematics without a profound understanding of fundamental math concepts. Bearing in mind the strategic position of a capstone course within teacher education programs, one of the primary goals of a capstone instructor is to make sure students have a thorough grasp of secondary mathematics concepts before leaving the higher education for their place of work as high school mathematics teachers. As Bob described,

So I think they need a place where they can ask questions that they would not have felt comfortable asking in other places. As an example, it’s not uncommon in this course for students to say something along the lines when I took number theory, I didn’t really understand this idea. Can we spend some time talking about this idea, which is sort of foundational number theory and I passed the class, but because I passed it now I can’t go back and admit that I don’t really understand it but I don’t understand it. So this class needs to be in place to be able to ask about that kind of thing.

Bob’s role is almost like personal tutor and mentor, which is beyond a typical course instructors’ role. Like Bob, other instructors similarly mentioned that mentoring includes tutoring, providing emotional support for prospective teachers, and establishing personal bond with them. Sherry’s approach was different. She had students pick a mathematics topic that they had difficulty with and conduct an in-depth research on that topic. She required literature review on the problem as well as providing examples of various approach to solving the issue. Her approach resembled an action research model as a way of fostering reflective practices among preservice teachers by emphasizing and posing questions and researching solutions. However, it is important to mention that other than Bob, Rebecca, and Sherry, the goal of culminating their previous learned concepts is not a dominant theme among these faculty members. Most instructors use capstone as a springboard for going out to the field.

Theme 3: Transition to Work

Like all other disciplines, mathematics education capstone faculty place emphasis on

transition to work. Having a previous k-12 experience, position the faculty members in an advantaged position where they can relate to the challenges of being a novice teacher in K-12 environment. They often introduce prospective teachers to what it is like to work as a teacher by sharing their personal experiences and inviting current school teachers to talk to them about the profession in general. The interviewees described their roles as someone who help pre-service teachers acclimate to the profession of teaching and provide a venue to socialize into K-12 professional environment. Other instructors invite current school teachers to talk to their students, and discuss professional related issues such as survival strategies, e.g., How to deal with a confrontational student. Linda also stresses the importance of networking by inviting local teachers, saying that local teachers “know how to use resource materials, they now how to find curriculum, they are familiar with the idea of networking with other professionals in their field.”

Capstone focuses on pedagogical skills, it also focuses on professional responsibilities and professional dispositions such as the ability to collaborate with the school community. The unique environment of capstone course can be used to help preservice teachers mentally ready for the profession. Alex shared what his students confide with him,

I'm very concerned about feeling overwhelmed can you just tell me that it's going to be okay? And so those kinds of questions are not, they don't really feel comfortable asking them in either content or other education courses so I think it is very important being that this is really there last chance before they go to student teaching. It is important that we are able to have that kind of relationship where they can ask those kinds of questions...I spend time each semester answering questions about potential jobs from previous students in that course. So they take the course, they go student teach, and then they send me emails asking about what you think about this place to work, or what should I do for my interview, or that kind of thing.

The capstone faculty's non-instructional role is based on holistic relationship with each student, which includes hand-holding role with respect to application and placement process. Several participating faculty mentioned that they often serve as a resource person or a mentor, answering technical questions regarding preservice teachers job search such as filling out jon applications, writing recommendation letters, even tutoring the math concepts that they were not able to grasp during the coursework. Most participants mentioned that they develop a strong relationship with the students which often continues after the semester, and sometimes after they graduate. Sherry believes that mentoring is a major part of the capstone course, stating “even though they're doing self-directed learning, there needs to be some scaffolding or support integrated within that.”

Becoming an independent learner is an important aspect of teaching profession (Estep, Anthony, & Allison, 2008). Bob and Linda focus on helping their students become independent learners by focusing on how to research topics, how to use library resources, and how to distinguish research-based information from opinions. Similarly, Sherry required that her preservice teachers use evidence-based research for their final project.

Theme 4: Reflective Thinking

Fostering reflective capacity among preservice teachers is the most dominant theme derived from the data. With regard to the first research question and regardless of their approach, all participants unanimously stated the importance of their role in helping PST to become reflective thinkers. Teacher education literature shows (Schon 1984; Zeichner & Liston, 1987), engaging teachers in reflection is one of the primary goals of university-based teacher education programs. Implementation approach varies by the participating faculty. Some capstone faculty encourage their students to reflect on their own practices, others encourage reflection on other teachers'—through observations or video analysis—teaching practices, while some faculty use existing teaching and learning literature as a reflective tool.

Bob is a prime example of illustrating the emphasis on reflective practices. He mentioned, “the important learning outcome is that they become deeply reflective about educational issues. ... the most important thing is their growth in reflecting their project.” Bob uses a wide range of reading materials to facilitate students' reflective thinking, which include: research articles, teacher's blog, New York Times, video clips. Like Bob, several instructors such as Arthur aim at exposing a wide range of pedagogical choices so that students have an extensive repertoire to reflect on. All participating instructors valued teacher's reflection, believing that teachers have agency to exercise their own practitioner's expertise. For that, teacher educators position themselves as facilitators who provide preservice teachers materials to develop reflective thinking. Don relates,

I try not to teach anything” teaching without teaching I am not so much interested in this course of producing clones of myself because I don't know how to teach necessarily. I am less interested in that they think like me but more interested in that they have thoughtful intent about every pedagogical choice that they've made

Don understands that teaching how to teach involves opening up a space for reflective capacity instead of solely inculcating specific techniques. Therefore, teaching skill directly, is not the main focus of capping courses. This is based on the belief that teaching is like an art, where individual's creativity and context-based knowledge comes into play. Arthur captures this point this way:

I can't teach teachers how to teach. I can't do it and I am not sure if anyone really can. All I can do is help teachers understand how they achieve teaching, the choice they are making in their teaching, and to be open minded to other things that could enhance their teaching. ... you can do nuts and bolts things, speak clearly write clearly. But in terms of the actual at of teaching? It really is an art. How do you teach painting a masterpiece? I mean you can say paint the brushstroke here or paint the brush over here, but essentially teaching painting is exposing somebody to a lot....

Like Don and Arthur, places a great emphasis on reflective practice as key characteristics of professional growth. All participating instructors claimed that their course adopts non-lecturing discussion-oriented approach. They mentioned that unlike the traditional content courses that contain lecture-quiz/test/presentation, capstone

requires more sophisticated instructional approaches. Don sums up, “hands off approach to letting them figure out their own answers that work well.” A majority of the participating instructors adopt a discussion as the main method. For example, Linda said she never stood in front of class.

Bob stated that he uses reading materials for a reflective exercise. He asks students to reflect on nonacademic topics such as math anxiety, research on successful high schools, research on international context, and how other countries teach math. Other instructors, integrate classroom observation with reflective analysis. Bob said, “they have to observe in a high school math class for 15 hours during the semester and they also have to design and teach a lesson in the high school classroom which they record and then they have to reflect upon that.” Research shows that observation alone is not an effective tool in learning how to teach (Berliner 2004) unless self-reflection is combined with observation (Stockero, 2008).

Similarly, Don assigns classroom observation and have them analyze the teaching: “We make them observe a classroom in motion and analyze the kind of questions that teachers ask...” Other instructors require a field experience, where the preservice teachers have to teach remedial classes with similar high school content at their university. Alex stated that

Since we don't have the luxury of having them go to the high schools to teach, we just figured that the best match for them would be teaching remedial math courses here and then they would journal about it, and we would look at the pedagogy behind that.

Some of the participating faculty fused video analysis within their curriculum. While some watched and analyzed preexisting videos, others required preservice teachers to videotape their own teaching followed by a self or group analysis. They use the clips to stimulate group discussion, to identify noticeable moments, and critique videos of teachers teaching. Alex, for example, use videotapes of actual classroom instruction and have the students' role play. A growing body of literature shows that using videos as instructional tools stimulate conversation about teaching and learning, increases the prospective teachers' attention on issues and aspects of teaching and learning (Stockero, 2008), and promote in-service teachers' reflective practices (Bliss & Reynolds, 2004; Hartford & MacRuairc, 2008; Santagata & Guarino, 2011).

The Role of Teacher Educators within Capstone Environment

Relevant to the first research question, our analysis shows that instructors straddle between three distinct roles when teaching capstone courses: university professors, practitioners, and mentors. Moreover, to answer the second research question, our data shows that a common goal of a capstone course across instructors is, by far, the attempt to bridge between practice and theory (McDonald, Kazemi, & Kavanagh, 2013). All instructors emphasize the importance of capstone course in bridging university and classroom. However, the way these two worlds are integrated in capstone varies depending on the way they view their role and selection of instructional approach.

University professor role. The participating instructors shares similar characteristics with other disciplines: culminating, practice-oriented, and transition to work. However, the emphasis on reflective practitioner is a noteworthy practice among teacher

educators (Britzman, 2000). As opposed to the apprenticeship model, the participating instructors implement the reflective practitioner framework. This emphasis on reflection is influenced by Schön's (1983) belief that teachers have agency to exercise their own practitioner's expertise. Since Schön's seminal book, *reflective practitioner*, teacher educators are aware that teachers are not mechanical trainees, but intellectual practitioners. The context specific aspect of teaching emphasizes the importance of viewing teaching profession as action and content specific, or as Schön refer to 'reflection-in-action' profession. Bob explicitly stated, "the students in the capstone course know they are near the end and in a lot of ways they feel unprepared ... So they are looking for some kind of apprenticeship model and we can't give them a direct apprenticeship."

Practitioner role. All except two of the participating teacher educators in this study stated that they had some K-12 teaching experience, and position themselves as someone who step outside of the university-professor role, and who could relate to their students through their practitioner experience. They help PSMTs embody professional identity by teaching real-life problems based on their experience. When instructing PSMTs in capstone setting, faculty were concerned with addressing professional issues such as career advice, fundamentals of professional interactions, interpersonal skills, and—personal issues. Capstone instructors provide real-life support beyond university-based coursework.

Mentor role. Another notable characteristics of the participating instructors is their belief in the importance of mentoring. Data repeatedly shows the theme of mentoring. Instructors respond to preservice teacher's anxiety and uncertainty. Because of its unique situation in teacher education where professors' teaching can be a model of teaching, they were aware of their responsibility to act as a role model, while shunning away from an apprenticeship model. The interviewees felt responsible for not only teaching a well-designed course but also to model a good "teacher." They build nurturing and caring relationship with each student.

While literature on mentoring novice teachers is extensive (e.g., Hobson, Harris, Buckner-Manley, & Smith, 2012; Hudson & Hudson, 2016; Olson, 2017; Redman, Conley, & Deal, 2015), research on the mentoring role of faculty, especially in capstone environment, is limited. The participating instructors expressed the importance of providing ongoing mentorship and support in helping novice teachers get acclimated into the profession. This is an important issue, considering the large rate of novice teacher turnover as well as the existing gap between American students mathematics performance and other developed countries (Galeshi, 2014).

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