The Consequences of Delayed Enrollment in Developmental Mathematics

By David S. Fike and Renea Fike

Abstract: ***Though a large percentage of U.S. students enter higher education with mathematics deficiencies, many institutions allow these students to decide the timing of their enrollment in developmental mathematics courses. This study of 3476 first-time-in-college students entailed the review of student outcomes (Fall GPA, Fall-to-Spring retention, Fall-to-Fall retention) for those who enrolled in developmental math during their first semester compared to those who delayed enrollment. The findings suggest that policy requiring mandatory enrollment during the first semester for developmental math students may be in the best interest of students and their institutions.***

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Research consistently reports the large number of students enrolling in postsecondary institutions with deficits in mathematics. Many institutions in the United States devote significant resources to the teaching of developmental-level mathematics courses. The National Center for Education Statistics reports that 72% of colleges and universities offer developmental mathematics courses and, nationwide, 24% of entering college freshmen are required to take developmental mathematics (Merisostis & Phipps, 2000). McCabe (2000) confirms these findings, noting that only 42% of students leave high school with adequate skills for college-level work; of these underprepared students, 62% are deficient in mathematics. Research has shown that more than one third of all college students are underprepared in mathematics skills (McCabe, 2003; Shults, 2000). The abundance of students needing remediation before enrolling in a college-level mathematics course presents challenges to postsecondary institutions and the students they serve.

Kinney (2001) states that students arrive at postsecondary institutions with deficits in mathematics for a variety of reasons: (a) they did not take the relevant courses in high school, (b) they took the relevant courses but did not master the content, and (c) they have forgotten much of the content that they once mastered. Bailey (2009) adds that "immigrants who had trouble understanding the English used in the math placement test" comprise another group coming to college who may show a deficit in mathematics (p. 1). Furthermore, according to Warner, Duranczyk, and Richards (2000) students may experience various levels of math anxiety or test anxiety leading to poor performance in mathematics courses. As a result, large numbers of students continue to enroll in college underprepared for the academic rigor of college curriculum (Boylan, 1995; Levine & Cureton, 1998).

Students who enter higher education inadequately prepared for college-level mathematics courses are frequently assigned to developmental mathematics courses with the goal of remediation. Many studies designate the role of developmental mathematics as a gatekeeper course for students (Fike & Fike, 2008; Johnson & Kuennen, 2004; Zhu, 2007). This means that students must be able to pass their developmental mathematics course in order to enroll in their college-level mathematics course. Passing the college-level mathematics course is required for college graduation. Knowing that many students struggle to pass their mathematics courses and understanding the critical role passing mathematics plays in college completion, institutions of higher education must do all they can to help students find success in mathematics coursework.

"Every postsecondary institution has the dilemma of placing incoming students into the appropriate first mathematics course" (Latterell & Frauenholtz, 2007, p. 8). Most higher education institutions have a college readiness standard; however, it may vary from one institution to another. This standard often consists of criteria, so that if the students meet all the criteria, they are deemed college ready. This means they do not need a developmental mathematics course. For example, many colleges and universities have internal placement tests. The score on the placement test dictates the level of mathematics in which the student may enroll. According to Bailey (2009) these assessments are, in reality, high stakes tests because failing such tests often leads to remediation in noncredit courses. Another option is the common practice of accepting Advanced Placement (AP) scores or dual credit courses as indicators of readiness to enroll at the college level. Another possibility is the utilization of ACT or SAT scores to indicate college readiness.

Although most institutions of higher education require scores for placement, many of them do not require students to be placed in courses based on the scores. "Mandatory assessment followed by

voluntary placement undermines the entire concept of assessment as a means of promoting student success" (Boylan, 2002, p. 36). Roueche and Roueche (1999) agree that leaving the decision to enroll in remedial courses in the hands of underprepared students is unjustified and ill advised. Higbee, Arendale, and Lundell (2005) support mandatory placement because "some students do not avail themselves of developmental opportunities for cultural reasons; some simply lack confidence or have not yet developed help-seeking behaviors" (p. 12). Not only is it important to place students at the most appropriate level in their first mathematics course, it is equally important to guide their enrollment so that they are taking the correct mathematics course at a time that will be most beneficial to them. Johnson and Kuenne (2004) found that students who delayed completion of a required developmental mathematics course did not perform as well in an introductory economics course as those who had successfully completed the required developmental course. Institutional policy regarding both mandatory placement and the timing of placement may have a bearing on students' academic success.

Commonly embraced standards for assessing the effectiveness of developmental education programs within higher education include student completion rates and grades (Boylan, Bonham, White, & George, 2000). This study looks specifically at these success measures relative to timing with regard to when the required developmental mathematics course was taken. For example, was the student required to take the developmental mathematics course the first semester of college enrollment or was the student given the option to defer taking the developmental mathematics course until a later semester?

The decades-long debate continues questioning whether students benefit most from being free to enroll as they wish or from having the institution take a prescriptive role in their progress through the curriculum (Berger, 1997). A study by Bettinger and Long (2005) has found that students placed in math remediation were 15% more likely to transfer to a four-year college, and they enrolled in approximately 10 more credit hours than their nonremedial counterparts. In addition, Roueche and Roueche (1999) have reported that remediation correlates with improved performance over the rest of the college experience (p. 47). According to the Commissioner of the Texas Higher Education Coordinating Board, "When an institution admits a student, it accepts the responsibility to do everything it can to help that student succeed" (Martinez & Martinez, 2006, p. 11).

When considering the impact that passing required mathematics courses has on student success, it is imperative for institutions to evaluate their assessment and placement policies. Most higher education institutions require entrance examinations to ensure college readiness; however, many do not regulate placement. Given the limited published empirical research regarding the impact of delayed enrollment in required developmental mathematics courses, this study was initiated to inform policy regarding the timing of required placement based on mathematics assessment scores and its impact on student outcomes.

Purpose of Study

The purpose of this study is to assess the impact of participation in a developmental mathematics course, if needed, during the student's first semester on student academic success and retention. It addresses the question of whether enrollment in developmental mathematics should be required during the first semester. The primary research question is, "For first-semester students who are not college ready in mathematics, are student outcomes (first-semester GPA, Fall-to-Spring retention, Fall-to-Fall retention) the same for those who successfully complete a developmental mathematics course during their first semester as compared to those who defer enrollment until future semesters?" The research hypothesis is that student outcomes, reflected in grades and retention, differ for those who successfully complete a developmental mathematics course during the first semester, compared to those who are college ready in mathematics, those who fail developmental mathematics in the first semester, and those who defer enrollment in developmental mathematics.

[Do] students benefit most from being free to enroll as they wish or from having the institution take a prescriptive role in their progress through the curriculum?

Method

Setting

The setting for this study is an urban, private university in the Southwest U.S. The university is designated as an Hispanic-serving Institution (HSI). The university offers baccalaureate, masters, doctoral, and professional degrees. About 700 first-time-in-college freshmen enroll each fall, with total annual enrollments exceeding 4,000.

Sample

The sample is comprised of all first-time-in-college (FTIC) freshmen who enrolled at the university during the fall semesters from 2005 through 2009. Data for the study were extracted from the institutional data warehouse, including admissions, transcript, and enrollment management data sources. Prior to data collection, Institutional Review Board approval was granted.

The dataset consisted of records for 3,476 students during their first year of enrollment in higher education. The data represented each student's freshman year for academic years beginning in 2005 through 2009, with roughly 700 students entering the university in each of the 5 years. Of these FTIC students, 884 (25%) were college ready in mathematics at initial enrollment, 1,139 (33%) enrolled in developmental mathematics during their first semester, and 1,453 (42%) deferred enrollment in developmental mathematics during their first semester. Although the students comprising the sample may have placed into other developmental courses such as reading, this study focused solely on developmental mathematics.

Variables

Student outcomes variables included the continuous variable, Fall GPA, and dichotomous variables, Fall-to-Spring Retention and Fall-to-Fall Retention. The primary independent variable was the students' first-semester math status (College Ready, Passed Developmental Math, Failed Developmental Math, or Deferred Developmental Math). College Ready in mathematics, based upon standards identified by the Texas Education Agency, was defined as either (a) an SAT Math score ≥ 500 and SAT Composite score ≥ 1170 or (b) an ACT Math score ≥ 19 and an ACT Composite score ≥ 23 (Texas Education Agency, 2010). Passed Developmental Math was defined as earning a grade of C or better. Covariates included Sex (Male = 1, Female = 0), Age in years, Race (White, Hispanic, Black, or Other), Resident (Resident = 1, Commuter = 0), High School GPA, Father Attended College (Yes = 1, No = 0), Mother Attended College (Yes = 1, No = 0), Received Needs-Based Financial Aid (Yes = 1, No = 0), and Semester Hours (hours enrolled during the first semester).

Statistical Analysis

Descriptive statistics were used to characterize the sample. Differences between subgroups within the sample were analyzed using Chi-Square for categorical variables and one-way analysis of variance (ANOVA) for continuous variables. Multiple regression was used to determine if Fall GPA was associated with first-semester math status while controlling for covariates. Logistic regression models were developed to determine if Fall-to-Spring and Fall-to-Fall retention were associated with first-semester math status. For regression models, categorical variables were dummy-coded. In the interest of parsimony, independent variables that were not statistically significant were removed from the models. Variance inflation factors and residuals

Table 1.

Sample Characteristics, Mean* ± SD *or* N*(%)

Variable	*N*[a]	College Ready (*n*=884)	Deferred Dev Math (*n*=1453)	Enrolled in Dev Math (*n*=1139)	Sig.[b]
Age	3476	18.05 ± .44	18.11 ± .92	18.16 ± .86	.013
Male	3476	327 (37%)	496 (34%)	345 (30%)	.006
White	749	347 (41%)	235 (17%)	167 (16%)	
Hispanic	2177	404 (48%)	977 (71%)	796 (74%)	
Black	205	34 (4%)	86 (6%)	85 (8%)	
Other Race	156	55 (7%)	72 (5%)	29 (3%)	< .001
High School GPA	3437	3.64 ± .28	3.43 ± .34	3.24 ± .37	<.001
SAT Math	3139	582 ± 53	475 ± 58	415 ± 52	<.001
ACT Math	1427	24.2 ± 3.0	19.2 ± 3.0	16.5 ± 1.9	<.001
Semester Hrs	3476	14.6 ± 1.5	14.1 ± 1.6	13.8 ± 1.6	<.001
Resident	3476	489 (55%)	694 (48%)	534 (47%)	<.001
Received Needs-Based Financial Aid	3476	228 (26%)	630 (43%)	544 (48%)	<.001
Father Attended College	2807	400 (54%)	447 (39%)	315 (35%)	<.001
Mother Attended College	2934	394 (52%)	480 (39%)	342 (36%)	<.001

Note. [a] *N*s < 3476 reflect missing data
[b] One-way ANOVA or Chi Square

were reviewed. Any cases with missing data were excluded from analyses. For all analyses, the level of significance was .05.

Results

Descriptive Statistics

Student characteristics are represented in Table 1. For each student's first semester, the student either (a) enrolled in developmental math, (b) deferred enrollment in developmental math, or (c) was college ready. Roughly a third of the FTIC students were males. Whites had a significantly higher representation in the college-ready group, whereas Hispanics and Blacks were more likely to enroll or defer enrollment in developmental math. Academic preparedness as measured by high school GPA, SAT Math score, and ACT Math score was highest for those deemed college ready, followed by those who needed but deferred enrollment in developmental mathematics. Students who enrolled in developmental mathematics were the least academically prepared. The college-ready group was more likely to reside on campus, more likely to have parents with some college education, and less likely to receive needs-based financial aid (a possible marker for socioeconomic status).

Multivariate Models

For all multivariate analyses, college-ready students represent the reference group. In other words, college-ready students (e.g., those who are best-prepared academically) serve as the standard to which other students are compared in this study.

A multiple regression model was developed with Fall GPA as the outcome variable (see Table 2). The model was statistically significant ($p < .001$), explaining 32% of the variance in Fall GPA. The model suggests that Fall GPA will be lower for males compared to females, lower for Hispanics and Blacks compared to Whites, higher for those with higher high school GPAs, higher for those whose father attended college, and lower for those who received needs-based financial aid. After controlling for the effects of these covariates, the model suggests that Fall GPAs for students who successfully complete developmental math do not differ from those of college-ready students. Students who defer enrollment in developmental math during their first semester have significantly lower Fall GPAs; their GPAs are expected to be about .285 lower than those who are college ready. Students who fail developmental math during their

Table 2.

Model Predicting Fall GPA: Multiple Regression[a]

Variable	Unstandardized Coefficients β	Standardized Coefficients Beta	*p*
Sex	–.176	–.087	<.001
Hispanic	–.095	–.046	.018
Black	–.222	–.056	.002
OtherRace	.032	.006	.729
HS_GPA	.716	.260	<.001
DadSomeCollege	.178	.091	<.001
RecvFinancialAid	–.103	–.053	.002
FailedDMath	–1.307	–.395	<.001
DeferredDMath	–.285	–.146	<.001
PassedDMath	–.094	–.041	.056
Constant	.730		<.001

Note. [a] Adjusted $R^2 = .315$

Table 3.

Model Predicting Fall-to-Spring Retention: Logistic Regression[a]

Variable	β	*SE*	*p*	Exp(B)
Sem_Hours	.136	.027	<.001	1.146
Sex	-.222	.090	.013	.801
Resident	.212	.086	.014	1.236
FailedDMath	-1.673	.156	<.001	.188
DeferredDMath	-.378	.114	.001	.685
PassedDMath	-.052	.132	.695	.950
Constant	-.798	.400	.046	.450

Note. [a] Nagelkerke R^2 = .106

first semester have Fall GPAs about 1.3 lower than those who are college ready.

A logistic regression model was developed with Fall-to-Spring retention as the outcome variable (see Table 3); the model explains 11% of the variance in Fall-to-Spring retention. In Table 3, the Exp(B) column provides adjusted odds ratios. Odds of Fall-to-Spring retention are higher for those enrolling in more semester hours, lower for males than females, and higher for residential students than commuters. After controlling for these covariates, the odds of Fall-to-Spring retention do not differ between students who pass developmental math and those who are college ready. The odds of Fall-to-Spring retention for those who defer enrollment in developmental math are 31.5% lower than those who are college ready. The odds of Fall-to-Spring retention for those who fail developmental math are 81.2% lower than those who are college ready.

A logistic regression model was developed with Fall-to-Fall retention as the outcome variable (see Table 4); the model explains 10% of the variance in Fall-to-Fall retention. Odds of Fall-to-Fall retention are higher for those enrolling in more semester hours, lower for males than females, and higher for students whose fathers attended college. The adjusted odds of Fall-to-Fall retention do not differ between successful developmental math students and those who are college ready. However, odds of retention for those who defer enrollment in developmental math are 28.5% lower than those who are college ready. Odds of retention for those who fail developmental math are 80.6% lower than that of college-ready students.

Table 4.

Model Predicting Fall-to-Fall Retention: Logistic Regression[a]

Variable	β	*SE*	*p*	Exp(B)
Sem_Hours	.120	.031	<.001	1.128
Sex	–.221	.100	.027	.802
DadSomeCollege	.339	.100	.001	1.404
FailedDMath	–1.640	.176	<.001	.194
DeferredDMath	–.336	.127	.008	.715
PassedDMath	–.086	.146	.554	.917
Constant	–.609	.461	.187	.544

Note. [a] Nagelkerke R^2 = .103

Summary of Results

At initial enrollment, rank order (highest to lowest) of students' academic preparedness was (a) students who were college ready in math, (b) students who needed but deferred enrollment in developmental math, and (c) students who enrolled in developmental math. In other words, those who enrolled in developmental math were the least academically prepared as measured by high school GPA, SAT, and ACT scores; they were less prepared than those who needed but deferred enrollment in developmental math. However, student outcomes (Fall GPA, Fall-to-Spring retention, Fall-to-Fall retention), ranked from highest to lowest, were (a) those who passed developmental math and those who were initially college ready [tied], (b) those who deferred enrollment in developmental math, and (c) those who failed developmental math (see Table 5, p. 8). Furthermore, of those who enrolled in developmental math, 71% completed successfully with a grade of A-C.

Discussion

Developmental mathematics programs differ by institution. Some institutions have a sequence of developmental mathematics courses whereas others have a single developmental course. Standards for placement and policy for mandatory enrollment differ by institution. All programs are ostensibly designed and implemented with the goal of remediating student skills and improving their prospects for academic success in higher education. However, these program differences may have a bearing on student outcomes. This study looked at the issue of first-semester enrollment (one specific policy characteristic of developmental mathematics programs) to assess its association with student outcomes. The findings suggest that allowing students who need developmental mathematics to delay enrollment may not be in the best interest of the students; policy requiring mandatory enrollment during the students' first semester may be of greater benefit to students and their institutions.

In this study, developmental mathematics students who successfully have completed a developmental math course during their first semester

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Table 5.

Student Outcomes (Ranked from Highest/Best to Lowest/Worst)

Ranking	Fall-to-Spring Retention	Fall-to-Fall Retention	Fall GPA
Best to Worst	Passed Dev Math & College Ready [tied]	Passed Dev Math & College Ready [tied]	Passed Dev Math & College Ready [tied]
	Deferred Dev Math	Deferred Dev Math	Deferred Dev Math
	Failed Dev Math	Failed Dev Math	Failed Dev Math

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achieve the same outcomes (First Semester GPA, Fall-to-Spring retention, Fall-to-Fall retention) as college ready students. This finding demonstrates the profound impact of developmental education on student success; in essence, it confirms the value of developmental education. Students successful in the developmental course "catch up" with the college-ready students.

Although study findings indicate that successful completion of a developmental mathematics course allowed "at risk" students to achieve parity in outcomes with students college-ready in mathematics, failure in developmental mathematics was associated with significantly poorer academic outcomes. Clearly, failure of the developmental course was one negative outcome, but outcomes for students who failed the course reflect broader adverse consequences including significantly lower first-semester GPAs and retention rates. This finding suggests that a focus should be placed on the effectiveness of developmental programs. Developmental mathematics outcomes have a measurable impact on overall academic outcomes, not just students' success in mathematics courses.

Delayed enrollment may be costly. Upon entry into higher education, students who needed but deferred enrollment in developmental mathematics were better prepared for academic success as measured by high school GPA, SAT math scores, and ACT math scores than those who enrolled in developmental courses during their first semester. Yet students who deferred enrollment had poorer outcomes than those who were college ready or those who successfully completed developmental math. Though the reasons for this finding are unknown, it may be that successful completion of a developmental course provides benefits beyond the course itself. The findings from this study suggest that first-semester mandatory enrollment may be of greater benefit than allowing students to choose when to enroll in developmental mathematics courses; the data provide no evidence that deferred enrollment will be beneficial to students.

Limitations

This was a retrospective study; causality cannot be established. Some data, such as student race and parent education level, were self-reported; these data were not validated. Some student records had missing data; these cases were excluded from analysis. Variables other than those included in this study (e.g., academic motivation, quality of instruction) may have a bearing on student outcomes. The single institutional setting also limits transferability of findings.

Implications for Future Practice and Research

The key implication for future practice is that implementing a policy of first-semester mandatory enrollment should be considered by institutions. Although this may present logistical challenges such as a greater need for trained faculty and classrooms for an increased number of sections in the fall compared to spring semesters, this policy may yield improved student learning and persistence. Prior to implementation of this policy, institutions may consider it prudent to confirm that similar findings apply to their students. Decision making should be informed by institutional data.

Perhaps students in developmental courses develop skills broader than those associated solely with course content; for example, perhaps students build study, time-management, and motivation skills which apply to all academic courses. Those who delay enrollment in developmental programs may not participate in courses with a focus on these broader issues. Further research is needed to identify the reasons why those who deferred enrollment in developmental math had poorer outcomes with respect to Fall GPA, Fall-to-Spring retention and Fall-to-Fall retention.

Another implication for future practice deals with completion rates; 29% of the students who enrolled in developmental mathematics in their first semester did not achieve a passing grade of A through C. It may be beneficial to craft developmental mathematics courses that target specific student profiles rather than using a "one size fits all" approach.

Tailored interventions may yield higher completion rates for developmental students. Since factors other than mathematics competence may influence academic outcomes in developmental mathematics courses, development and use of diagnostic tools that are more comprehensive and predictive than traditional placement exams may facilitate tailored interventions. For example, some students may need to participate in a learning community consisting of reading, study, and mathematics skills. Others may benefit from tutoring, supplemental, or self-paced instruction. Additionally, early alert systems should be designed and implemented to identify students who need intervention and support early in their first semester. By identifying unique needs of developmental students, tailored interventions specifically targeted at these needs may promote greater pass rates in developmental mathematics and lead to improved overall academic outcomes.

Future research should be conducted to confirm the findings from this study based upon different environments such as community colleges, institutions with multiple levels of developmental mathematics and institutions with diverse student populations. Longitudinal research should be pursued to assess the long-term impact of mandatory placement (e.g., graduation rates, GPA at graduation). Studies exploring the impact of developmental mathematics on student performance in other subjects may be beneficial. Additionally, research regarding the consequences of delayed enrollment in other developmental courses (e.g., reading) should be pursued. Developmental education may provide benefits beyond mere acquisition of content-specific knowledge and abilities. Since developmental programs focus on students at risk, perhaps developmental students develop study skills, time management skills, motivation, and other attributes which benefit them throughout their academic experiences. These lines of inquiry will help inform and guide improvements in developmental education.

Conclusion

This quantitative study has assessed the consequences of delaying enrollment in developmental mathematics for first-time-in-college students who were not college ready in math. The findings suggest that students who defer enrollment in developmental mathematics may have less desirable outcomes as measured by Fall GPA, Fall-to-Spring retention, and Fall-to-Fall retention, which supports establishing policy requiring mandatory enrollment in developmental math courses during their first

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semester for students who are not college ready. Improved success and retention is in the best interest of the students and their academic institutions. Further research is needed to better inform policy regarding the timing of required placement of students in developmental programs. Connections between success in developmental and regular content courses should be considered in developing such policy in order to maximize effectiveness. The vitality of developmental programs within higher education will be sustained and strengthened through proactive implementation of evidence-based policies which promote improved student outcomes.

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NADE News: Challenge to Take Ownership

By Rebecca Goosen, NADE President

The new semester has descended on us all with both new and familiar faces arriving on our campuses ready to begin or continue their education. Although some of us have had a hiatus, the national conversation on developmental education has continued with vigor. Mike Meotti, Connecticut Board of Regents for Higher Education, recently stated that to move from a place of apathy to a place of innovation will involve making people uncomfortable. Well, the folks in Connecticut have managed to do that. Our current systems are weighted by history, not necessarily need. NADE does not support all of the actions of the state of Connecticut, but there is something to be said about being brave and undertaking change that utilizes the "Big Bite Theory" of dramatic scaling to change a status quo.

The call to enter the conversation is urgent, and it takes more than a few to address the issues. Developmental education needs to take ownership of this challenge, and NADE acknowledges that there is a need to change things that are not productive for students. We must always remember that students are the center of this discussion. They are not just a number in a study. Students have a face and a name; they are individually important in this discussion. NADE agrees that more research needs to be conducted in the field; however, it is also important to do so responsibly and include those individuals who actually understand the students involved.

Many NADE members have questioned where the developmental education professionals have been in the decisions and discussions that are occurring around the country. Actually, many of you are involved in those discussions. NADE has been well represented at many of the national gatherings discussing developmental education across the country. A short list would include NADE's participation at the Accelerated Learning Programs conference in Baltimore, National Center for Public Research conference at Columbia University, American Association of Community Colleges conference in Orlando, NISOD conference in Austin, Developmental Education Initiative-Achieving the Dream State Policy meeting in Miami, and just last week at a gathering of individuals in Washington, DC that included a number of foundations, professionals in the field, and leaders and experts in developmental education who came together to work on a national action plan for developmental education. Many of you have shared questions and concerns on the educational list serve or presented/informed at state and local meetings with information that has added to the conversation. All of these efforts are examples of how you as professionals are having a voice in the conversation, and rest assured, it is being heard.

In addition to the National Action Plan for Developmental Education, NADE has also worked with the National Center for Developmental Education to organize a plan around what good developmental education programs should encompass. Please take the opportunity to network with your colleagues and learn more about the national conversations concerning developmental education by joining us at the national conference in Denver from February 27th through March 2, 2013

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