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Investigating Content Knowledge of Traditionally vs. Alternatively Prepared Pre-service Secondary Mathematics Teachers

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Abstract

Teacher content knowledge has been repeatedly linked to student achievement. Alternative Mathematics Teacher Education Programs are popular and prevalent, but do they prepare teachers with the content knowledge needed to teach secondary mathematics? This study reports on a quantitative analysis comparing scores between traditionally and alternatively prepared teachers on a secondary mathematics state licensure test. Results show that neither group had a passing mean, and traditionally prepared teachers typically score higher on the state licensure test, though only significantly higher in particular domains and total score.

Introduction

Alternative Teacher Education Programs (ATEPs) have been a source of heated debate for many years. Proponents for such programs see ATEPs as a means for progressive, accelerated courses of study for teachers. Further, ATEPs may have the ability to recruit highly skilled individuals (such as second career teachers or mathematics and science majors) who might not otherwise find their way into the field of education and can provide an expedited path to an advanced degree for in-service teachers. Opponents to these programs believe that ATEPs circumvent important components of teacher preparation in favor of expediting the process. As such, opponents believe that ATEPs provide a less rigorous route to teaching that weakens the overall quality of the teaching force while undercutting traditional programs and may in turn produce less qualified teachers.

Alternative Teacher Education Programs

ATEPs, which we will define as “teacher education programs that enroll non-certified individuals with at least a bachelor’s degree offering shortcuts, special assistance, or unique curricula leading to eligibility for a standard teaching credential” (Adelman, 1986, p. 2), currently exist in all 50 states in the U.S., as these programs can provide ways for universities and school districts to address teacher shortage and recruitment issues rapidly. There are many examples of ATEPs that have started locally based on such needs and have gained national recognition. UTeach, for example, which began at the University of Texas at Austin, recruits students who major in the Natural Sciences into the field of teaching, providing them with various levels of support and opportunities for learning through field-based experience. In theory, such programs allow the university to produce highly qualified teachers with a great deal of content knowledge to surrounding school districts. This model has been expanded to other institutions around the country. Teach for America (TFA, not technically a certification program) also recruits mainly non-education majors and has extremely high standards for admission into their program. These recruits are trained and eventually placed in high need urban schools that usually serve high populations of minority students and those living in poverty. As such, TFA aims to provide a much needed resource, highly qualified teachers, to struggling schools. Other ATEPs aim to recruit populations that are underrepresented in education, such as people of color (because the teaching force is still largely white) and males into the field (Shepard, 1999).

Despite the important and lofty goals set forth by ATEPs, many of the programs are still seen as sub-par shortcuts to the classroom. Some teachers who have gone through ATEPs report feeling underprepared for the classroom and perceive a lack of support from programs (Foote, Brantlinger, Haydar, Smith & González, 2011). Lack of funding, poor school-program communication, and lack of appropriate mentors may contribute to these issues. Many factors, however, keep the business of developing ATEPs lucrative. In recent years, for example, ATEPs have been promoted by state and national governments. In 2002, the U.S. Department of Education proposed ATEP programs as a way to not only increase teacher quality but also meet the then growing demands for highly qualified teachers. Moreover, the U.S Department of Education (2004), in The Secretary's Third Annual Report on Teacher Quality supported ATEP programs, calling the teachers it prepares "highly qualified".

Research on Student Achievement

Adding to the "hot" topic of debate of ATEPs is whether graduates of traditional teacher education programs, are in general, more effective as related to student achievement, than those receiving certification by an alternative certification program. Some studies have shown that students of teachers who are traditionally prepared score higher on standardized tests (Marszalek, Odom, LaNasa, & Adler, 2010). This is often attributed to the idea that alternatively certified teachers may have strong content knowledge, but do not have strong pedagogical content knowledge (Desimone & Long, 2010) necessary to impact student achievement. In reading this work, however, it seems that there may be other factors at play. Generally, alternatively certified teachers are recruited to teach in high need schools that traditionally score lower on standardized tests than their suburban counterparts. This may skew the achievement data and misrepresent the effect of the teacher preparation program on student achievement. Overall, there is very little evidence that truly proves that alternative certification is detrimental to student achievement (Peterson & Nadler, 2009), as these outcomes are largely affected by other factors and the program itself.

Research on the impact of teacher certification tracks on student achievement is mixed and inconclusive. After controlling for other factors, such as poverty, Darling-Hammond (2000), found teacher preparation to be the strongest factor in student achievement in mathematics. Darling-Hammond, Holtzman, Gatlin, and Heilig (2005) correspondingly showed that alternative certification has a negative effect on student achievement. Goldhaber and Brewer (2000), however, found that teacher certification tracks had no impact on student achievement in mathematics.

Empirical research investigating mathematics teachers' credentials, in general, agree that strong teacher mathematics content knowledge seems to correlate to improved student mathematics test scores at all levels (Goldhaber & Brewer 1999; Hill, Rowan, & Loewenberg, 2005). Other studies have found correlations between secondary mathematics teachers' content-focused professional development and mathematics achievement of their students (Harris & Sass, 2007, 2009). Further, teacher scores on mathematics licensure tests seem to be a fairly strong indicator for future student achievement in mathematics (Sawchuk, 2011). Several researchers claim that the findings are mixed in this area when looking at subjects other than mathematics (Clotfelter, Ladd & Vigdor, 2007).

Successful ATEPs

Given the prominent role of ATEPs in the field of education, particularly in mathematics, much work has been done to study the key elements of successful programs. In addition to rigorous coursework and fieldwork, effective ATEPs should have a mentoring component facilitated by qualified individuals who can offer a strong support system to ATEP teachers (Feistritzer & Chester, 2003). This piece has been emphasized in many research studies focused on ATEPs (Chesley, Wood & Zepeda, 1997; Jorisson, 2002). More specific findings, such as those reported by Suell and Piotrowski (2007), identify critical components of ATEPs. Suell and Piotrowski (2007), for example found: (1) The recruitment of minorities; (2) Careful selection; (3) On-the-job training; (4) Coaching; and (5) Accountability to be vital to the success of an ATEP. The Education Commission of the States (2003) summary of studies, found: (1) Strong partnerships between preparation programs and schools; (2) Good screening; (3) Strong mentoring; (4) Solid curriculum; (5) As much training and coursework as possible prior to teaching were key components of a successful ATEP. Overall, these factors varied widely among studies, and largely seem to depend on the goals of the program, the population from which and for which participants are being recruited, and the structure of the ATEP.

The literature base on the success of ATEPs is inconclusive and points to the need for more research focused on the outcomes of these programs. Further, much of the literature in this area does not report on particular content areas, but rather programs in general. There is a clear need for research that compares subject-specific programs and outcomes.

Purpose of the Study

As mathematics educators at a large, public university in the south (we will call it Sothern U (SU)) that houses both traditional and alternative mathematics teacher education programs, we strive to engage in ongoing program analysis efforts in order to review student outcomes on a regular basis. Further, given the correlation between teacher mathematics content knowledge and student achievement, we sought to investigate the preparedness of our graduates in terms of content knowledge. Thus, in this study we gathered and analyzed data related to student passing rates on the state certification secondary (high school) mathematics exam. Students must pass this exam in order to receive certification to teach in a high school mathematics classroom; as such, it is an important indicator of our program effectiveness. We looked at student score data overall and as they relate to individual mathematics teacher education programs at our university (i.e. various routes including traditional, post-baccalaureate (PB), and our in house ATEP). We also looked at particular content domain scores for students in each program, which will give us insights as to specific strengths and weaknesses of each route to certification.

This type of program evaluation is especially important at our Hispanic serving institution, as there is a shortage of teachers of color in mathematics classrooms (Howard, 2006). Further, given the large populations of minority and low income students in the urban area in which the university is situated, it is imperative that our programs prepare teachers for success in seeking teaching certification and effective pedagogy in the mathematics classroom. These analyses will provide programs with important statistical data relating to mathematics teacher preparedness for the content certification exam and, ultimately, the secondary mathematics classroom. Further, these data will provide specific feedback to programs relating to content areas in which our students excel, and those areas in which students struggle. Ultimately, we sought to determine if teacher preparation tracks have an impact on pre-service teacher success on the certification exam for secondary mathematics.

SU Overview

Currently, approximately 30,000 students are enrolled in over 126 undergraduate and graduate degree programs at SU. Students who seek certification to teach secondary mathematics have several options or routes available to them. The traditional certification plan is for undergraduate students who wish to major in mathematics while taking courses in the College of Education (COE) throughout their undergraduate program. Students who are non-traditional can seek certification through a post-baccalaureate program or through the Alternative Teacher Education Program (ATEP), housed in the COE.

Traditional Certification Plan. Students at the undergraduate level seeking secondary mathematics certification go through SU's traditional certification plan, housed largely in the Department of Mathematics. These students complete the bachelor's degree requirements in their academic specialization (in our case, mathematics) while coordinating with the COE to fulfill certification requirements and coordinate additional experiences such as practica and student teaching. If a student chooses to seek certification in two teaching fields, they still must obtain a bachelor's degree in one field and a teaching certificate in the second area. Ultimately, students in this track complete at least 45 hours of mathematics content courses, including Modern or Abstract Algebra, Real Analysis, and a Capstone Course for Mathematics that focuses on connections between college and high school level mathematics.

Accelerated Teacher Education Program. SU offers several alternative certification options for students seeking secondary mathematics teaching credentials, one of which is housed in the COE. The organization that funds the program operates on the premise that due to the large number of minority students now enrolled in our schools, teacher preparation programs must focus their attention on preparing teachers to meet the needs of ethnic minorities. Further, SU is a Hispanic-serving institution (HSI) in a city with a largely Hispanic population, so another major role of the academy is to prepare and retain teachers of color. This, coupled with the current teacher shortage in critical areas such as mathematics education, bilingual education, special education and science education, drives the program's Alternative Teacher Education Program (ATEP). The ATEP program aims to prepare culturally efficacious teachers in high needs areas, offering a graduate-level program leading to EC-12 Special Education, 4-8 Math, 4-8 Science, 4-8 Math/Science, 8-12 Math, or 8-12 Science certification.

ATEP is a post-baccalaureate program that recruits college graduates with STEM or human-service related degrees and second career professionals. Applicants to ATEP must have a bachelor's degree in some field and must be able to gain admission to the COE. Upon admission, these students begin taking graduate coursework that allows them to work toward certification and their master's degree simultaneously. This coursework includes 24-27 hours of certification courses and a "core" of graduate level coursework in the COE. Students are also

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required to complete 8 online learning modules, participate in an online ecommunity of practice, attend summer and weekend workshops (such as the Summer Bilingual Institute), and complete 30 hours of field observations. Further, the funding organization partners with several high need districts in the area, which helps with job placement, observation opportunities, and networking.

In addition to content-based preparation, ATEP aims to prepare teacher candidates to become culturally efficacious by implementing a holistic approach taking the students' academic, personal, and professional experiences into account as they develop their craft. As such, ATEP not only focuses on pre-service teachers' academic understanding but also focuses on psychosocial, personal, and professional domains that are central to the practice of teaching through an intensive mentoring program. The program works with teachers in the transition to the classroom and beyond certification in an effort to ensure that teachers of color not only enter the classroom but stay there for many years, ultimately meeting the needs of the diverse populations they serve (Flores, Clark, Claeys, & Villarreal, 2007).

Post-baccalaureate Program. In addition to ATEP, SU offers a post-baccalaureate (PB) certification plan for secondary mathematics certification. The PB program is generally meant for students who already have a bachelor of arts Degree in business or other area, and have come back to school to get a certification in order to become a teacher. After their certification, they can generally apply those credits towards a Master's Degree.

Generally speaking, the traditional track is considered to be more content intensive, whereas the PB tracks (including ATEP) focus more on pedagogy, issues in education, and support for beginning teachers. We sought to investigate these notions of traditional vs. post-baccalaureate mathematics preparation of teachers in an effort to improve at the program level.

Methodology

As professors who teach courses in each of these programs, we have anecdotally noticed differences in content knowledge within and between students in each program. Most notably, many students demonstrated a lack of content knowledge when asked to apply basic concepts. This concerned us, as "teachers' knowledge of mathematics is positively related to student achievement" (National Mathematics Advisory Panel, 2008, p. 37). Since most SU students complete the secondary mathematics certification exam at or near the end of their program, we considered that this standardized measure would allow us to investigate how prepared our pre-service teachers are for the classroom in terms of content. In addition, we sought to determine if the type of preparation a student received had an effect on his or her chances of passing the state certification exam. We hypothesized that students who were prepared under the traditional degree plan would pass more often than ATEP and PB students, as the traditional program is much denser in terms of mathematical content.

Scores on the state certification exam from the years 2006-2010 from 69 students, labeled as 'Traditional' and from 20 students, labeled as 'ATEP/PB' were analyzed to determine if there were significant differences that could reflect their content and pedagogy preparation. We combined PB and ATEP students because both tracks are completed post-baccalaureate and because it gave us a larger sample. Although students with an overall failing score (less than 240) are allowed to re-take the test in its entirety, only results from their initial (first) attempt are used in the calculations of average scores.

A Total Score and six Domain Scores are used in the calculations. The domains are:

Domain I: *Number Concepts*
Domain II: *Patterns and Algebra*
Domain III: *Geometry and Measurement*
Domain IV: *Probability and Statistics*
Domain V: *Mathematical Processes and Perspectives*
Domain VI: *Mathematical Learning, Instruction, and Assessment*

Research questions that guided our analyses are:

1. How do total scores on the secondary mathematics state exam compare among SU students between the two different tracks to certification (traditional vs. ATEP/PB)?
2. How do SU student domain scores on the secondary mathematics state exam compare between these two programs?
3. Is there a significant difference in the number of attempts it takes for students in the two programs to pass the exam?

Findings

Means and standard deviations are calculated for each of the categories of Total Score, Domain I, Domain II, Domain III, Domain IV, Domain V, and Domain VI.

Table1

Summary of Means

	Mean Total Score I	Mean Domain I	Mean Domain II	Mean Domain III	Mean Domain IV	Mean Domain V	Mean Domain VI
ATEP/PB	223.75	231.20	226.95	224.15	219.80	212.60	226.35
Traditional	245.36	241.26	246.33	241.19	241.00	242.78	231.61

Table 2

Summary of Standard Deviations

	S.D. Total Score	S.D. Domain I	S.D. Domain II	S.D. Domain III	S.D. Domain IV	S.D. Domain V	S.D. Domain VI
ATEP/PB	30.61	27.65	26.35	40.77	37.12	34.22	26.61
Traditional	28.87	26.55	27.33	31.89	30.12	29.88	33.99

The mean values of the exam scores from traditional students are greater than the mean values of the ATEP/PB students for Total Score and all six domains. Every domain for the students enrolled in the traditional program had an average score of at least 240 (passing), except for Domain VI (*Mathematical Learning, Instruction, and Assessment*). None of the means for ATEP/PB is at the passing level. Since the scores of the traditional students are not normally distributed, we could not use *t*-tests, but had to employ nonparametric statistics to determine any significance between the distribution of scores.

The first two research questions were investigated using the Wilcoxon Rank Sum Test for two independent samples since the Kolmogorov-Smirnov Tests indicated that the scores from the traditional students are not normally distributed. The Wilcoxon Rank Sum Test is a non-parametric hypothesis test for determining if one of two independent samples has values that are systematically larger than the other. The null hypothesis states there is no systematic difference in rankings. It requires samples to be independent and observations to be ordinal (ranked). The *p*-values represents the probability of error in rejecting a null hypothesis when it is actually true. We used a significance level of .05; *p*-values less than .05 indicate sufficient evidence to reject the null hypothesis of no difference. The last research question is investigated using a chi-square test to determine if there is any significant difference in test attempts between students in the two test groups.

Research Question 1. *How do total scores on the high school level mathematics TExES exam compare among SU students between the two different tracks to certification (traditional vs. ATEP/PB)?*

The null hypothesis, H_0, states there is no difference between distribution of total scores for SU students from a traditionally prepared program and distribution of total scores of SU students in an alternative and/or post-baccalaureate program (ATEP/PB).
H_0: There is no difference in scores between the two groups.
The alternative hypothesis is:
H_a: There is a difference in scores between the two groups.

Table 3
Total Score

	n	W= rank sum statistic	p-value
ATEP/PB	20	595.5	0.002807*
Traditional	69		

Note. *Result is significant

Since our *p* value is less than .05, we reject the null hypothesis and conclude that the distributions in the two groups differ significantly. 'W' is the rank sum statistic and represents the sum of ranks for ATEP/PB in a ranking using all scores from both groups.

Research Question 2. *How do SU student domain scores on the high school level mathematics TExES exam compare between these two programs?*

This null hypothesis, H_0, states that there is no difference in distributions of domain scores for SU students from a traditionally prepared program and distributions of domain scores of SU students in an alternative and/or post-baccalaureate program (ATEP/PB). For each of the six domain scores a null hypothesis is formulated and evaluated separately.

Domains. Each of the six domains in the exam was examined for the students enrolled in an alternative (ATEP/PB) program and those in a traditional teacher preparation program. The domains include: Number concepts, Patterns and Algebra, Geometry and Measurement, Probability and Statistics, Mathematical Processes and Perspectives, and Mathematical Learning, Instruction, and Assessment.

The null hypothesis, H_0, and the alternative hypothesis, H_a, for each domain can be expressed as follows:

H_0: There is no difference in the domain score between the two groups.
and
H_a: There is a difference in the domain score between the two groups.
We test each hypothesis for Domains I through VI with the Wilcoxon Rank Sum Test.

Table 4
Wilcoxon Rank Sum Test

Domains	ATEP/PB (n)	Traditional (n)	Wilcoxon Rank Sum Test	*p*-value
I	20	69	751.5	0.1457
II	20	69	600	.003241*
III	20	69	738.5	0.1135
IV	20	69	671	0.0247*
V	20	69	539.5	0.0004023*
VI	20	69	736.5	0.1091

Note. *Results are statistically significant

For domain I (Number concepts), since $p > .05$ (two-tailed test) the two samples are not significantly different. Therefore, we cannot reject the null hypothesis. For domain II (Patterns and Algebra), $p < .05$ (two-tailed test), the two samples are significantly different. Therefore, we reject the null hypothesis and accept the alternative hypothesis that there are statistical differences in scores between the traditional group and the ATEP/PB group. For Domain III (Geometry/and Measurement), our *p*-value does not meet the .05 level so we cannot reject the null hypothesis. Additionally, since $p < .05$ (two-tailed test), the result is statistically significant for Domain IV (Probability and Statistics). The null hypothesis is rejected and we conclude that there are significant differences in scores. For Domain V (Mathematical Processes and Perspectives), the value of $p < .05$ indicates statistical significance so the null hypothesis is rejected and we conclude that there are significant differences in scores between the two groups. The *p*-value for Domain VI (Mathematical Learning, Instruction, and Assessment) is greater than our pre-set value of .05, so we cannot reject the null hypothesis in this case.

Summary of Results. There is insufficient evidence that there are significant differences in domain scores between the ATEP/PB and traditional groups of students for Domain I (Number Concepts), Domain III (Geometry and Measurement), and Domain VI (Mathematical Learning, Instruction, and Assessment). For Total Score, Domain II (Patterns and Algebra), Domain IV (Probability and Statistics), and Domain V (Mathematical Processes and Perspectives) we reject the null hypothesis and maintain that distributions in the two groups differed significantly.

Research Question 3. *Is there a significant difference in the number of attempts it takes for a student to pass the exam between the two programs?*

Descriptive results. We first look at the descriptive results and then conduct a chi square analysis to determine significance. Eighty-one percent of the traditionally prepared students passed the exam, with 75.4% passing on their first try. Ninety percent of the ATEP/PB passed the state exam during this time period, with 55% passing on their first try.

The analysis examined the scores for *all* attempts for Traditional and ATEP/PB students since there were 26 students, or 29.2% of the total 89 students, who failed at the first attempt and had to re-take the test, some multiple times. Seventeen out of the 69 traditional students, or 24.6%, and nine of the 20 ATEP/PB students, or 45%, had re-takes.

Table 5

% Students taking and retaking test

	Total test takers	# re-takes	% re-takes	Average times for re-takes	# eventually passing	% re-takers passing
ATEP/PB with re-takes	20	9	45%	3.11	7	77.8%
Traditional with re-takes	69	17	24.6%	3.06	4	23.5%
Total	89	26	29.2%	3.08	11	42.3%

Of the 17 students enrolled in a Traditional teacher preparation program with re-takes, only four (23.5%) eventually passed (See Table 6), while seven of the nine (or 77.8%) ATEP/PB students with re-takes eventually passed (See Table 7).

Table 6

Seventeen Traditional Students with Re-takes

Student	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
# Tries	2	2	2	2	4	3	2	2	3	3	4	4	3	2	4	2	8
Pass?	N	Y	N	N	N	N	N	Y	N	N	N	N	Y	N	Y	N	N

Table 7

ATEP/PB Students and Traditional Students with Re-takes

Student#	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
#Tries	2	7	2	2	4	2	4	3	2
Eventually pass?	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes

Two of the ATEP/PB students and 13 of the students prepared in a traditional program never passed the exam during the years we examined.

Chi square analysis. We examine the last research question by defining a null hypothesis.

H_0: Among those that passed, there is no difference between the two groups in the distribution of number of attempts.

Alternative hypothesis is:

H_a: Among those that passed, there is a difference between the two groups in the distribution of number of attempts.

A chi square analysis was done with the data described in the following Table 8.

Table 8
Chi Square analysis

	Passed 1st try	**Passed 2nd try**	**Eventually passed**	**Total**	**Chi Square**	***P***
ATEP/PB	11	5	2	18	11.48	.0032
Traditional	52	2	2	56		

The results indicated a χ^2 value of 11.48 and a *p*-value of .0032. This indicates that there is evidence against the null hypothesis so we maintain that there is significance in the number of attempts to pass the test between students in the ATEP/PB program and students prepared in the traditional program. However, three of the cells have small values, which might have affected significance.

State-Wide Comparison. An additional discussion issue is the comparison of passing scores of SU students, in both programs, with state-wide passing scores. While no direct comparisons or statistical analyses can be made, it is interesting to examine the state-wide average and the SU average. Neither average is at the passing level of 240.

Table 9
State-wide vs. SU Averages

	SU	State-wide
Mean	239.14	230.94

Additional Discussion

Our findings indicate that there are significant differences in scores on the secondary mathematics licensure test between traditionally prepared and ATEP/PB students in the following areas: Total Score, Domain II (*Patterns and Algebra*), Domain IV (*Probability and Statistics*), and Domain V (*Mathematical Processes and Perspectives*). As such, we can conclude that a student who is prepared in a traditional program is more prepared for the secondary mathematics licensure test. This seems logical, as traditionally prepared secondary mathematics teachers generally have majored in the subject, giving them a great deal more content knowledge. It is interesting to note, however, that neither group had an average score that qualified as passing, indicating that students from both programs may need more support in the content presented on the licensure test. This was also true state-wide, though SU's mean score was 9 points higher that the state average. These low means may indicate one of the following: (1) teacher education programs are not preparing pre-service teachers well for the licensure exam, (2) the content represented on the licensure exam is not aligned with content taught in teacher education programs, or (3) the licensure exam is not a valid or reliable test. Additional research is needed in these areas.

Given that the literature suggests that higher scores on licensure tests lead to increased student achievement (Sawchuk, 2011), we may be able to conclude that traditionally prepared teachers have a better chance at positively affecting student mathematics achievement, particularly in the areas indicated in domains II, IV, and V. This conclusion may be too simplistic, however, as many factors contribute to teacher success. ATEP students, for example, are provided with transitional mentors who continue to work with teachers as they transition into the classroom. This, in addition to the online community of practice that is central to the ATEP program, may negate content deficits suggested in this analysis. On the other hand, traditionally prepared teachers have been working towards teaching for a longer period of time, and have more content hours, which may set them up for success. More research in these areas is needed to draw any causal relationships from these data. For example, we hope to conduct a follow-up study wherein we collect qualitative (observation and interview) data that would allow us to determine if the test is a good predictor of classroom success.

In conclusion, it seems that traditionally prepared teachers at SU have greater content knowledge than those prepared in alternative tracks. We believe this is a significant finding in terms of programs and literature that reports on ATEPs as student achievement is tied to teacher content knowledge.

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