Student self-assessment of mathematical skills: A pilot study of accounting student

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ABSTRACT

When new students arrive at university to commence their undergraduate training they bring with them a host of prior experiences, expectations and beliefs. For students whose course of study includes mathematics these experiences, expectations and beliefs can be very strongly held and somewhat negative towards mathematics. In such cases they can become a barrier to further learning in mathematics. This paper reports on a small pilot study exploring the mathematical experiences, expectations and beliefs of accounting students with a view to improving their engagement with mathematics. The results of a student survey allow the identification of students whose self-assessments and expectations are not congruent with their observed performance with a consequent risk of disengagement from mathematics.

Keywords: student engagement; quantitative skills; Accounting; student expectations.

Introduction

How well do we know our students? How well do our students know themselves? Both are important questions in the context of students new to higher education (HE) as the former impacts on curriculum design and teaching strategies at first year level while the latter can influence student engagement and retention particularly if student academic self-perceptions turn out to be overly optimistic. Unfortunately it is often the case that in recruiting new students for HE it is entry qualifications that take precedence over a more informed assessment of the student's previous educational experience or their perception of their own strengths and weaknesses.

In this paper we focus specifically on the mathematical skills of students undertaking an accounting course in the UK HE sector. This focus is brought about by worries over the preparedness of students to study quantitative subjects in HE which has been of concern to educators and the UK Government for some time. In fact these concerns prompted the UK Government to commission a report into mathematics education (the Smith Report) which found that the perception of many young people was that mathematics is boring and irrelevant and that there is a perception among non-specialist students that mathematics is difficult (Smith, 2004). Although things have subsequently improved through educational reforms at secondary level there are still concerns within HE that students are not engaging with the elements of mathematics appropriate to their course. Norris (2012) makes the point that "English universities are side-lining quantitative and mathematical content because students and staff lack the requisite confidence and ability" (p.11) reporting also that "40% of employers have found that employees and prospective employees lack even basic numeracy skills" (p.11).

Furthermore it is recognised that having to study mathematics may invoke quite strong negative feelings within students due to perhaps not having studied the subject for some time, having had poor prior experiences of learning mathematics, of not seeing its relevance, or of just 'not getting it'. This has led to a large and growing research literature responding to perceived problems with mathematical anxiety (Furner & Berman, 2004), mathematical self-efficacy (Bandura, 1997) and the need to provide students with additional mathematical support to cover weaknesses in subject knowledge (Symonds, Lawson & Robinson, 2008).

This paper builds on previous work in the teaching of mathematical skills (Warwick, 2012; Warwick & Howard, 2014) and focuses on the self-perceptions of accounting students towards mathematics as they begin their university education. We report on a pilot study designed to help better understand these students and their perceptions and explore how they may impact on student engagement with, and performance in, mathematics.

Mathematics in the Accounting Curriculum

The UK Quality Assurance Agency (QAA) publishes subject benchmark statements which define what can be expected of a graduate in that subject. The QAA subject benchmark statement for Accounting (QAA, 2015) defines some of the required knowledge and skills to be "analysis of the operations of business … financial analysis and projections … and an awareness of the contexts in which accounting data and information is processed and provided within a variety of organizational environments" (p.7). Furthermore the benchmark statement emphasises that there should be an underpinning of generic quantitative skills that include the processing and analysis of financial and other numerical data and the appreciation of statistical concepts.

Although, of course, many of the detailed calculations required of accountants are now accomplished by computer software, there is still a need to engender in students a fundamental understanding of mathematical ideas and skills. Indeed it has been appreciated for some time that the professional accountant must have "… the ability to interpret and question results [which] can only really come from a fundamental understanding of how those results have been generated." (Francis, Spencer & Fry; 1998, p.26).

Thus the continued study of mathematics and quantitative methods is fundamental to the development of the work-ready accounting graduate despite the all-embracing presence of information technology and even though students are required to have a GCSE in Mathematics (or an equivalent qualification) for entry to UK universities experience has shown that the mathematical ability of the incoming students is very varied (Perkin, Croft & Lawson, 2013). Accounting course curricula invariably reflect the requirements of the professional bodies and employers but this does not necessarily mean that students are willing to engage with the mathematical content of courses to the extent that educators would like.

It might be expected that students who are choosing to undertake a course in a numerate discipline (such as accounting) would have the requisite skills and would hold positive beliefs and attitudes towards the study of mathematics. This has not been found to be true. Tolley et al (2012) found that entrants to higher education engineering courses were in need of remedial mathematics training and report that the problem seems particularly acute for engineering majors. Ward et al (2010) discuss a number of negative attitudes towards mathematics that they found in their calculus ready students and Mokhtar et al (2010) found similar traits exhibited among engineering students. If such negative attitudes are exhibited among STEM students then it must be assumed that they will also be found among accounting students although to date there has been little research relating specifically to the perceptions of mathematics among accounting students.

Student Engagement with Mathematics

A number of models of student engagement have been proposed and reviewed in the literature (Christenson, Reschly & Wylie, 2011; Kahu, 2013; Zepke, 2014). Trowler (2010) discusses the fundamental dimensions of engagement and recognises three key dimensions as emergent:
behavioural engagement (attendance at classes, behaviour during classes etc.), emotional engagement (affective responses to studying such as interest in the subject, enjoyment, enthusiasm) and cognitive engagement (wanting to learn, going beyond prescribed tasks, questioning and encouraging others). Effective student engagement will involve recognition of the importance of all three dimensions by the student and, conversely, failure in one dimension will often impact on the others and the result will ultimately be disengagement by the student.   Appleton et al (2006) discuss the dimensions of engagement, the contexts influencing them, and examples of their respective indicators while Warwick and Howard (2014) discuss a causal loop model of engagement emphasising the feedback mechanism that can make the link between engagement and student outcomes operate as either a virtuous or vicious circle.

Aspects of the three dimensions of engagement have been explored by teaching practitioners to find ways in which each dimension can be encouraged within students to enhance the likelihood that the engagement feedback process becomes a virtuous rather than vicious circle. Behavioural engagement can be encouraged by, for example, careful timetabling of sessions, of monitoring student attendance or of awarding summative assessment marks for attendance and contribution to classroom activities. Similarly cognitive engagement can be influenced by the learning and

teaching approach adopted, the style of classes etc. (Wahid & Shahrill, 2014). There is also evidence to suggest that problem based learning approaches can significantly improve cognitive engagement (Rotgans & Schmidt, 2011) and that learning partnerships and student support are important in developing cognitive engagement in mathematics (Duah & Croft (2011).

What is less clear though is how we can explore students' emotional engagement with mathematics. This is important as although students may be very motivated to study mathematics because they wish to succeed on their course of study, their emotional response to having to undertake mathematical training at university can be a significant inhibitor to future mathematics learning through impact on both behavioural and cognitive engagement dimensions. This exploration is particularly important when students first join the university but we actually have very little information about our students' perceptions of mathematics when they first arrive at the university and for a subject such as accounting it is important that we engage students in a virtuous circle of engagement, learning, successful outcomes, improved engagement etc.

We align our thinking regarding emotional engagement with researchers such as Malmivuori (2006) who emphasise the strong interconnections between mathematics thinking and self-perception. Students are viewed as constantly interpreting and evaluating their experiences and regulating their behaviour in interaction with their mathematics learning environment. All forms of environmental feedback (both informal from their own observations or more formally from their tutor) are examined by the student through a process of self-reflection and behaviour is modified which, in some cases, may mean poorer engagement.   What can be particularly problematic for students are 'shocks to the system' when outcomes of assessment or learning experiences do not match their own expectations.

This paper therefore explores aspects of new accounting students' feelings and expectations regarding mathematics (i.e. the contributors to emotional engagement) and whether self-assessments of their mathematical abilities were accurate as students with inaccurate assessments may become quickly disillusioned with their chances of success and disengage from study (Warwick, 2009) producing reductions behavioural and cognitive engagement.   In particular the research sought answers to three research questions.

On entry to their course to what extent are accounting students' perceptions of their mathematical skills accurate?
To what extent do accounting students' previous experiences and expectations provide indicators of potential mathematical performance?
How can we use this information to work with mathematically weak students to improve self-assessments and engagement?

Methodology

In September 2015 some 60 students joined the university to embark on a Foundation Degree in Accounting and a sample of 40 were asked to complete an expectations questionnaire in which students were required to indicate the extent to which they believed a set of statement applied to them by using a five-point Likert scale (ranging from 1 = not true to 5 = very true).

Based on previous research (Warwick, 2012), the questionnaire contained 24 statements which were designed to elicit student self-judgements relating to their:
previous education and expectations - Statements here were:
I think I can pass the mathematics test on this module,

> *I was expecting to study mathematics on this course,*
> *I have always done well in maths classes*

emotions and confidence - Statements here were:
> *I am generally confident about getting arithmetic calculations correct,*
> *I like studying mathematics,*

general abilities and mathematical awareness - Statements here were:
> *I am generally good at mental arithmetic,*
> *I can do calculations without a calculator,*
> *When doing arithmetic, I can tell if my answer looks correct or not,*

self-assessment of specific mathematical skills - Statements here covered a range of skills including fractions, percentages, ratios indices etc. and included statements such as:
> *When multiplying or dividing numbers I know how to deal with negative numbers,*
> *I know how to add and subtract fractions without a calculator.*

These types of statement relate directly to two of the three dimensions of student engagement namely emotional engagement and cognitive engagement.

For the statements relating to specific mathematical skills (those in group d) responses from each student were averaged across all the skills examined to give a general indicator of the student's belief in their strength in these specific quantitative skills. Scores for the other eight statements in groups a-c were each scored by students from 1 to 5.

One of the key modules on the first year of the Foundation Degree in Accounting that develops mathematical skills is the module Professional Skills. This module covers a range of general and study skills as well as developing a range of mathematical skills including those of calculation, algebra and statistics. Conventionally the module has used a diagnostic mathematics test to ascertain which students are strong in the core skills, and which are perhaps in need of additional support and remedial teaching. The diagnostic mathematics test was designed to assess their basic knowledge of arithmetic, algebra and linear equations. This provided us with additional evidence as to the basic mathematical skills possessed by these students which we later use in this paper to partition the group broadly into strong and weak students.

Thus for each student in the sample we had a self-evaluation of their key mathematical skills (the average response to statements in group d above), a record of their performance in the diagnostic test, and their responses to the eight statements in groups a - c listed above giving a total of ten measures. We also had background information about each student relating to their gender and their age.

Results and Discussion

For all data analysis non-parametric statistical tests were used. With a small sample of data and using Likert scale data (which many would regard as ordinal data at best) it was felt appropriate to use non-parametric tests which make no assumptions about the underlying distribution of any of the response variables.

We first calculated the average score for each of the ten response items averaged across the student sample and listed them in decreasing order as shown in Table 1. In addition, we tested each of the ten indicators to see whether there were any detectable differences between responses depending on gender or age. The results are also shown in the final two columns of Table 1.

Table1:
Responses Compared by Age and Gender

Response Item	Average response (all students)	Gender p value (two tailed)	Age* p value (two tailed)
Specific mathematical skills	3.8	0.342	0.119
I think I can pass the mathematics test on this module	3.7	0.386	0.809
I have always done well in maths classes	3.7	0.745	0.358
I can do calculations without a calculator	3.6	0.978	0.114
I am generally good at mental arithmetic	3.4	0.329	0.181
I am generally confident about getting calculations correct	3.4	0.371	0.452
I like studying mathematics	3.4	0.892	0.250
I can tell if my answer looks correct or not	3.3	0.315	0.850
I was expecting to study mathematics on this course	3.3	0.787	0.263
Diagnostic test score	72.6	0.432	0.760

* Age coded into three groupings: 17-18; 19-25; over 25.

Since there were no statistically significant differences by gender or age among the ten response items all subsequent analysis was conducted using the entire sample of students as a single group.

The statements with the highest average level of agreement relate to the students' self-evaluation of their specific mathematical skills, their expectation of being able to pass the module, and their previous experience with mathematics. However, having a liking of studying mathematics is towards the bottom of the list and, surprisingly perhaps for accounting students, there is a relatively low level of agreement with the statement 'I was expecting to study mathematics on this course'. In fact of the 40 students there were 11 who responded with either 1 or 2 on the questionnaire and so must have been somewhat surprised to see the study of mathematics as part of their course. Ensuring that students are fully aware of course content is an issue that needs to be addressed for incoming students before they arrive at university.

Table 1 also indicated that the average level of agreements for all the response variables was above the Likert scale mid-point of 3 and this augers well for at least initially good engagement (emotionally and cognitively) with the mathematical elements of the module.

Generally, then, students strongly agreed that they could undertake those skills that were to be measured in the diagnostic test and were confident of passing the summative assessment in mathematics. We then used the data to explore each of the research questions in turn.

Question 1: On entry to their course to what extent are students' perceptions of their mathematical skills accurate?

We first calculated the sample Pearson correlation coefficient (denoted as r) between the students' self-assessment of their mathematical skills and their diagnostic test score. This produced no significant correlation (r = 0.246, p = 0.125). This would imply that the students' judgements about their mathematical skills are poor and hence there may be an impact on engagement when the their true level of ability is made apparent through the diagnostic test or in classes. Clearly the most significant impact would be on those students who have over-estimated their abilities. To explore this a little further we divided the scores for the diagnostic test into two

groups – those above the median score who we would regard as potentially good students with few weaknesses and those below the median who may be in need of further support. We then produced a box-plot of each group showing their self-assessments of specific mathematical skills. This is shown in Figure 1.

Figure 1:
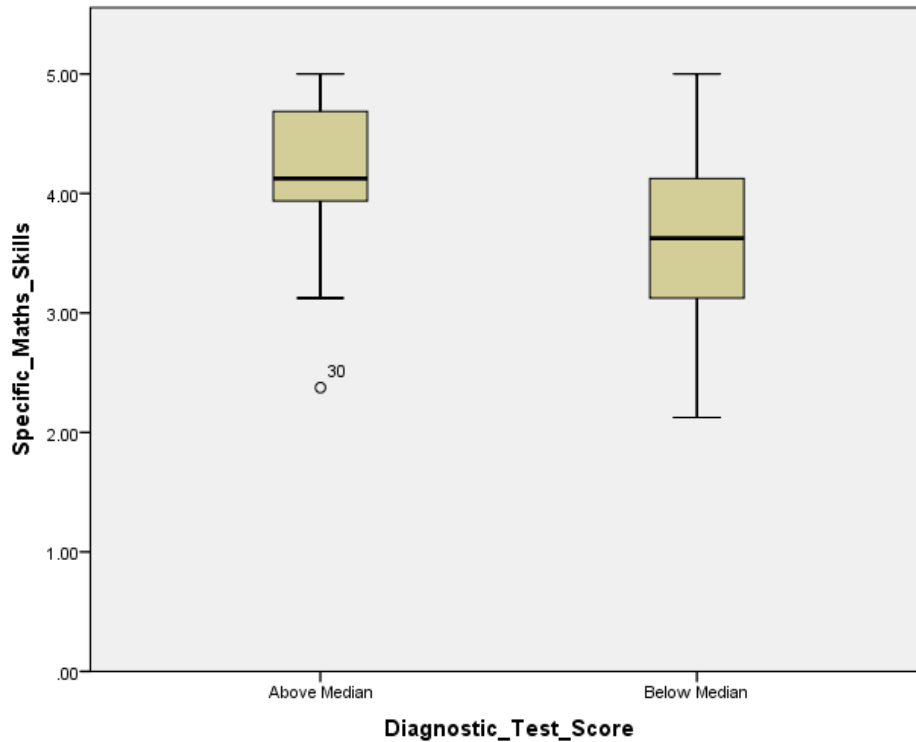*Specific Maths Skills Judgements for Weaker and Stronger Students*

Figure 1 shows how the students' perceptions of their specific mathematical skills differed between the two groups. Using a Mann-Whitney U test the null hypothesis that the distributions are the same is rejected ($p = 0.014$) so we can conclude that the weaker students hold different perceptions of their mathematical skills when compared with the better students. Figure 1 illustrates that the better students have a higher median score for their self-perception which is to be expected and that they seem to have a more consistently accurate perception of their abilities i.e. the spread of values is smaller. It is among the weaker students where there seems to be much greater variation. This effect has been noted in the literature as the Dunning-Kruger effect (Kruger & Dunning, 1999). Dupeyrat et al (2011) for example state that "*overestimation occurs mainly in unskilled or incompetent subjects because incompetence not only causes poor performance but also the inability to accurately evaluate one's performance*" (p.247).

Now, for students who are at risk of failing in mathematics it has also been noted that "*Traditional academic feedback (i.e. grades) provides little adaptive help to at-risk students and often leads instead to counterproductive, defensive reactions*" (Zimmerman et al, 2011; p.109). Thus use of standard diagnostic tests with the intention of simply backfilling uncovered gaps in knowledge is likely to be of little benefit to these students. It seems to be the case that some weaker students have unreasonably high assessments of their basic skills and this has significance for both emotional and cognitive aspects of engagement as students come to realise that they are perhaps not as able in basic mathematical skills as they thought.   What is indicated is a need to work with the weaker students identified through the diagnostic

test to correct their perceptions of the mathematical abilities and provide them with a programme of support that can both fill potential gaps in their knowledge but also allow them to reflect appropriately on their progress with mathematics and develop appropriate self-regulated learning capabilities.

Question 2: To what extent do students' previous experiences and expectations provide indicators of potential mathematical performance?

In order to explore whether these qualitative self-judgements can have any currency in helping staff identify the weaker students on entry we amalgamated the response items to calculate an average score for each student for each within each group a to c above. We then calculated the sample Pearson correlation coefficient for each of these groupings against the diagnostic test score and the results are shown in Table 2.

Table 2:
Sample Pearson Correlation for Response Groups with Diagnostic Test Score

| Response group		r	p
a	Previous education and expectations	0.376	0.020
b	Emotions and confidence	0.594	0.000
c	General abilities and mathematical awareness	0.543	0.000
d	Specific mathematical skills	0.246	0.125

With the exception of the self-assessments of mathematical skills (mentioned previously) there is statistically significant correlation between the average scores for groups a to c and the diagnostic test results. The implications of this are that these data can help us to learn more about our students but in particular more about those students who seem to be expressing views that are not in keeping with the general pattern of correlated results shown in Table 2.

To explain this in more detail we have taken response group with the highest correlation (group b) and produced a box-plot of student responses against the diagnostic test results this time subdivided into quartiles. This is shown in Figure 2.

We can see that this group of responses differentiates between the students of differing abilities quite well but that there is still some considerable overlap between the box plots. In other words although the median score reduces as we move down through the quartiles, there are students who are in the lowest diagnostic test quartile (quartile 1) and therefore potentially quite weak mathematically who have expressed the same self-assessments as students in quartiles 3 or 4. Identifying those students whose self-assessments do not tally with their test performance provides material that could be explored by teaching staff working with students during the seminar sessions as these views may be optimistic (in which case further reflection by the student would be required) or entirely appropriate in which case perhaps there are other reasons for the poor diagnostic test performance.

Figure 2:
Distribution of Scores for 'Emotions and Confidence' by Diagnostic Test Score
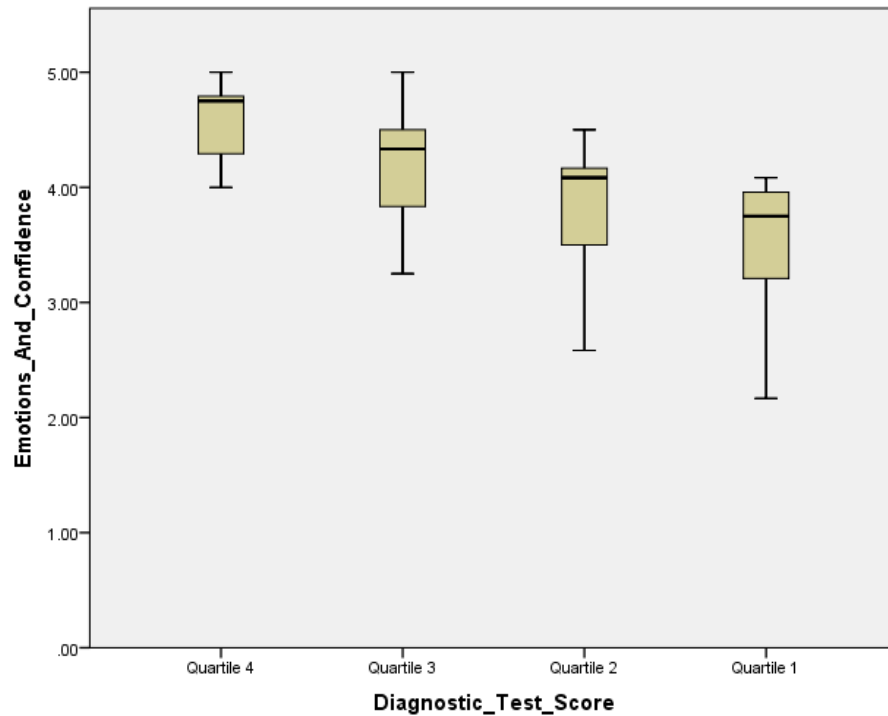
An example from our pilot group would student 6. This student had a diagnostic test score that placed him in the first quartile and so he was a student at risk of failing. His scores for the four groups of questions though are shown below in Table 3, which also shows where the score rates in terms of the whole student sample.

Table 3:
Specific Student Profile

	Student score	**Position in whole sample**
Previous education and expectations	4.00	60th – 70th decile
Emotions and confidence	3.67	20th – 30th decile
General abilities and mathematical awareness	3.33	30th – 40th decile
Specific mathematical skills	4.13	60th – 70th decile

There are two clear anomalies in this student's self-evaluation. Firstly his assessment of previous education and expectations and second his evaluation of his own specific mathematical skills. These scores are both much greater that the other students in the lowest quartile of diagnostic test scores and in fact are consistent with students in quartile 3. His diagnostic test score would presumably have come as somewhat of a shock.

This process could be repeated for all students with poor diagnostic test scores.

Question 3: How can we use this information to work with mathematically weak students to improve self-assessments and engagement?

There is a developing literature on the ways in which students can be supported to correct knowledge deficiencies in mathematics (Perkin, Croft & Lawson, 2013; Lawson, Croft & Waller, 2012). However less attention seems to have been paid to understanding and correcting students' misconceptions of their abilities. Dunning (2013) offers some interesting thoughts on this in the context of the workplace but we believe that these ideas translate into student settings as well. The key is to set in place a feedback dialogue with the student so that expectations and self-assessments can be adjusted by the student through a process of reflection by the student and amendment to learning behaviour. If this is to be successful then Dunning recommends that feedback should have three distinct characteristics.

First it should be clear and unambiguous. Feedback which is ambiguous or contradictory will most likely be interpreted by the student in a way which sustains any misapprehension that the student may have rather than correct it.

Second, it should be delivered in such a way as to avoid any defensive reactions from the student. This could easily take the form of reduced engagement by the student or even non-engagement in the extreme. To achieve this the feedback should be delivered in small doses but regularly, should be decoupled from any perceived severe consequences for the student (withdrawal, module failure, reduction in grades etc.) and should focus on changing learning behaviour rather than calling into question subject competence. Unfortunately, it is often the case that a rigorous diagnostic test at the start of a module can be perceived as failing on all three counts and may induce defensive behaviour from the student.

Third, the feedback requires follow-up. We see this dialogue with the student as being a regular occurrence undertaken through seminar sessions but requiring one-to-one or small group sessions with those students identified as at risk of failure.

Using this feedback dialogue with students we would hope to be able to engender changed reflective learning behaviour and improved self-assessments of mathematical ability leading to improved cognitive engagement with learning together with better emotional engagement with mathematical study.

Conclusion

Many institutions now use diagnostic tests to assess the mathematical capabilities of their students at entry. This pilot study has illustrated the potential value of collecting additional qualitative information from students that can be of assistance in identifying students with self-assessments at variance with their existing skills. This will help us to work with these students at enhancing engagement, or at least preventing disengagement, of students from mathematical study. A diagnostic test alone can highlight gaps in knowledge, but as a form of feedback to students it can be perceived as having significant consequences for the student, is oriented towards competence rather than behaviour, and may well induce a defensive reaction of disengagement from the student. Thus we would advocate working with the weaker students to provide corrective feedback that corresponds to the criteria described earlier by Dunning (2013).

This is just a preliminary study. We have not attempted to ascertain where any negative perceptions of mathematics originated and we have not attempted to delve more deeply into the educational backgrounds of our student sample. However, given the lack of research focussing on accounting students we feel that it will be worth

repeating this study with a far larger sample of students and undertaking a qualitative analysis of their reactions to an improved feedback dialogue with their tutors and an attempt to correct misguided self-assessments.

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