

RESEARCH ARTICLE

## First-year seminar intervention: Enhancing first-year mathematics performance at the University of Johannesburg

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### *Abstract*

South Africa has opened up access to higher education over the past 20 years. The massive increase in enrolments (with almost 70% first-generation students) substantially affects progress and graduation rates in Science programmes in higher education. First-year students in Science realise that university mathematics requires knowledge and skills that are not part of their academic repertoires. Science students at the University of Johannesburg register for a two-week, credit-bearing First-year Seminar (FYS). The research question that this paper addresses is: What is the relationship between the First-year Seminar and the mathematics performance of first-year students in Science? The specific purpose is to determine the relationship between: (1) students' school mathematics background; (2) the problem-solving skills sessions of the FYS; and (3) their first-year performance in mathematics. It was found that the FYS enhances students' ability to make a successful transition to university, with problem-solving ability acting as a fair predictor of performance in first-year mathematics. The empirical data was collected through a before-and-after test performed by the 2014 cohort with regards to students' attendance of the FYS. Notably, the data indicate that the value added by the problem-solving test can be applied to identify and engage students who have high probability of becoming students at risk (STARS).

### *Keywords*

Higher education, teaching and learning, first-year student experience, mathematics performance, University of Johannesburg, South Africa.

### *Introduction*

The South African higher education sector became more aware of the need for a dedicated institutional first-year experience (FYE) in 2009, when Stellenbosch University hosted a national FYE conference (Leibowitz, Van der Merwe & Van Schalkwyk, 2009, p. 3). Since then, the nature of first-year programmes and their possible role in academic

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success have been widely researched, in particular with respect to attempts to counteract possible negative influences of the secondary schooling system (Jacobs, 2010). Currently, approximately one in eight Engineering and one in four Science students graduates in the expected number of years (Council on Higher Education [CHE], 2013, p. 37). These throughput rates are a matter of national concern and impact on the country's economy.

South African higher education enrolments have grown by almost 90% between 1994 and 2012 (from 495 356 to 937 455) (CHE, 2013, p. 37). Unfortunately, however, low participation and high attrition rates prevail. Many students from diverse academic backgrounds were excluded due to the apartheid regime and are now accessing higher education institutions (HEIs) in pursuit of qualifications (Tait & Godfrey, 2001). This is particularly true for students enrolled for Science programmes (Giancola, Munz & Trares, 2008). The country's public schooling system does not seem to prepare students adequately for higher education (Jacobs, 2010), with inflated school marks and a lack of academic literacies being quite common (Nel & Kistner, 2009). More than 70% of first years have first-generation status (CHE, 2013, p. 45), generating additional challenges for these students, caregivers and first-year lecturers (Bowl, 2001).

It is almost as if the sector has come to accept that schools will not be able (at least, in the short to medium term) to prepare school-leaving students better for higher education, and especially with respect to Science programmes (Jacobs, 2010). Science faculties therefore design formal intervention programmes (Kift, 2008) to prepare their first-year students for academic and other institutional challenges. These programmes typically strive to enhance students' confidence levels by exposing them to an enabling environment aimed at the development of their coping mechanisms. This paper places a lens on such a First-year Seminar designed by the Faculty of Science at the University of Johannesburg (UJ).

The research question that this paper seeks to address is: What is the relationship between the aforementioned FYS and the mathematics performance of first-year students in Science? A specific purpose is to assess the import of students' performance in the problem-solving component of the FYS in relation to their first-year mathematics achievement later in their first year of study.

### *Transition and adaption*

the transition of first-year students from school to higher education has been explored and interrogated at length in a number of studies, namely Briggs, Clark and Hall (2012), Jacobs and Jacobs (2013) and Kift (2009), amongst others. Science students are literally caught in a substantial "gap" between school and university education (Sappa & Bonica, 2008), mainly because the subject content of science programmes continues from where schools should have left off. Although Winterson and Russ (2009) encourage schools and universities to make the transition process easier, South African schools are typically challenged by a shortage of qualified teachers, poorly maintained facilities and a lack of resources (Jacobs, 2010). Spaul (2014) indicates that, in South Africa, only one in four mathematics teachers is sufficiently trained in mathematics.

Although school education authorities (e.g. Volmink, 2010) constantly deny that students' final marks might have been inflated, research-based interrogations by universities prove otherwise (Nel & Kistner, 2009). Without blaming the school, Briggs, Clark and Hall (2012) argue that students entering higher education make a personal investment using their cultural capital, which was accumulated through their prior education at school. Many students thus enter with a "currency" that might be foreign to the institutional culture. Lecturers need to identify and acknowledge this, while trying to support students to adapt to higher education expectations by exchanging their "currency" for relevant and required knowledge and skills.

The need for adaptation for a successful student "identity" is amplified when first-generation students enter the new higher education environment (Briggs, Clark & Hall, 2012). This first stage of transition (Huon & Sankey, 2002) occurs when students learn to behave like "real" university students (Fazey & Fazey, 2001). In fact, studies on student expectations and decision-making by Peel (2000) and Tranter (2003) reveal a discrepancy between the aspirations and the experiences of first-year studies. Students' lack of self-knowledge and uninformed decision-making relating to their choice of studies often lead to withdrawal and eventual dropout (Hillman, 2005; James, 2000).

### *First-year programmes*

First-year transition has been researched internationally since the 1970s (Akerlind, 2005, p. 1). While dedicated structures and programmes are well established in the United States (such as the Centre for Academic Enhancement at the University of Georgia) and have gained ground in Asian, Australian and European higher education (Meyers & Ryan, 2008), South African institutions of higher education have been trying to convince faculty and governance structures that this is, indeed, part of their scope. Lecturer champions and a few supportive deans are still persuading other stakeholders that formalised orientation (induction) programmes for transitional students (Kift, 2008) are non-negotiable.

First-year programmes provide first-year students with support systems that focus on making the adjustment to university life easier. The internationally renowned scholar Vincent Tinto (2008, p. 14) has listed the vital institutional factors that enhance student academic success, namely that a student should: be socially and academically integrated; identify with peer groups (although Science students often feel alienated); be integrated into the institutional culture; and become an involved student.

At the University of Johannesburg, the Faculty of Science has been actively supporting first-year students since 2004. Increasing numbers of unsuccessful students, lecturers who kept on complaining about underprepared first-years, and growing institutional pressure to enhance student throughput were the main catalysts behind the launching of the Faculty's FYE (on an informal basis) in 2005. Four years later, a more formalised FYE programme was approved. The programme posits 10 principles, of which the following three are noteworthy: it is incumbent on the university to ensure that students are provided with enabling learning environments; the FYE is not envisaged as simply assisting students to pass, but as enabling as many as possible to achieve their full potential; and the challenge of

first-year teaching requires special expertise from the academic staff, who must in turn be assisted in meeting these challenges (UJ, 2009, p. 4).

Lecturers and senior students in the Faculty of Science have been engaging with first-year transition in two formal structures in the last decade. The First-year Seminar (FYS) and the First-year Academy (FYA) focus on the entering students and the lecturers teaching them respectively. The FYA has been developed to give mainly first-year lecturers the opportunity to discuss and contemplate similar challenges they may encounter while teaching vulnerable and highly expectant first-year students. The FYA also provides a platform for very necessary peer and senior support in teaching and learning.

The FYS in the Faculty of Science occurs two weeks before formal classes commence, and seeks to assist first-year students with their transition to higher education. The programme involves students (from all study areas) who are enrolled for science modules (such as mathematics, physics and chemistry); it includes workshops in laboratory skills, mathematical problem-solving and academic literacy for science in its curriculum. FYS students also participate in sessions on time management and study skills, and are introduced to various support services on campus. They get to know the campus as soon as possible by competing in groups in an “amazing race” game, modelled on the reality television show. Groups receive a map of the campus and are expected to visit indicated points of interest. Upon completion, the groups present photos (on their smart devices) as evidence that they have, indeed, visited the specific points of interest. This allows them to get to know the campus in a fun and exciting way as well as to cooperate with fellow students.

Pascarella and Terenzini (2005), as well as Keup and Barefoot (2005), find that the active participation of first-years in an FYS has a huge positive effect on their ability to make the adjustment from school to university as well as on retaining them until their second year of study. The FYS allows students to become aware of and recognise the level of their personal academic skills. The Seminar also creates a safe learning environment that provides students with relevant learning opportunities geared to the development of essential skills for the various disciplines in Science. Erickson, Peters and Strommer (2006), and Pascarella and Terenzini (1991; 2005) all agree that FYS programmes have the capacity to create an environment in which students can develop the critical thinking skills needed for their intellectual growth.

The core components of the programme include three focused modules in language, mathematical problem-solving and laboratory skills development. The first component is five (two-hour) sessions focusing on academic literacy (language). Bowl (2001) emphasises that non-traditional students may struggle to write scientific reports and essays; these language sessions serve as opportunities for the students to learn how to improve their reading and writing skills with a specific focus on Science modules. The second component is five (two-hour) sessions focusing on solving mathematical problems with a special focus on bridging the gap in content knowledge from school to university. The third component comprises of three (two-hour) laboratory sessions, in which students are introduced to the Chemistry, Physics and Biology laboratories and are familiarised with various items of laboratory equipment used for different experiments – many of the first-year Science

students come from rural schools and have never been introduced to laboratory work.

Carefully selected staff present sessions in various disciplines (Mathematics, Physics, Life Sciences, Chemistry and Geography). Winterson and Russ (2009) point out that students have to become accustomed to various learning styles, referencing techniques, as well as note taking. Research and the writing of academic essays and reports are an integral part of higher education studies. The first-years also participate in a session with the Science librarian, where they tour the library and draft a short essay, having to use the Internet, an academic journal, a Science textbook and an electronic database.

The Faculty of Science established its FYA in 2007. It serves as a community of practice for lecturers of first-year students, thereby promoting Ernest Boyer's Scholarship of Teaching (and Learning) (Boyer, 1997). The FYA undertakes research into the strategies and the roles of lecturers in dealing effectively with transitional students (Jacobs & Jacobs, 2013). Adaptions to academics' customary roles are recommended and the Academy acknowledges that changes in role expectations may lead to role ambiguity and conflict among the lecturers, to the potential detriment of the faculty. However, appropriate lecturer behaviour and duties and also expected competencies have to be identified and developed if the faculty continually wants to enhance the academic success of its growing number of transitional students.

### *Research method*

this paper analyses the test results from a purposive (convenience) sample of 360 of the 1 060 students who were also enrolled for a specific module in first-year Mathematics (Mathematics 1A). Before and after the 2014 FYS, all participants (first-year students) completed a test, with 25 multiple-choice questions containing items on language, mathematics and laboratory content. All sample members participated in the pre- and post-FYS test in problem-solving and their school mathematics results were available.

A demographic analysis of the participants indicates that just less than one in four is female; slightly more than one in five had English as the primary home language; and 80% are Science students, with the remainder being enrolled for Engineering. The data were collected and aimed at determining the students' content knowledge in respect of laboratory, language and problem-solving (quantitative literacy) skills. Respondents were requested to complete the test upon the first day of arrival and the same test was administered on the last day (of the two-week programme). Student's final school (Grade 12) and end of first semester results in mathematics were also captured. Descriptive statistics, cross-tabulations and frequency distributions were conducted via the Statistical Package for the Social Sciences (SPSS, version 22).

In 2014, the pre- and post-tests on the three above-mentioned constructs were administered for the first time. The 2014 investigation thus served as a pilot study and its reliability will be determined in the near future. Specialist lecturers in respect of the three test components designed the test items; this ensured the content validity of each item.

### Research findings

The sample of 360 first-year students presented the following scores (all percentages): for pre-FYS problem-solving,  $M = 45.44$ ,  $SD = 19.444$ ; for post-FYS problem-solving,  $M = 62.86$ ,  $SD = 18.188$ ; for school (Grade 12) mathematics,  $M = 73.18$ ,  $SD = 10.173$ ; and for first-year Mathematics (MAT1A),  $M = 48.74$ ,  $SD = 1.663$ . These scores are further analysed in the three tables that follow.

Table 1 presents a cross-tabulation of Grade 12 versus first-year Mathematics (MAT1A) scores at various intervals.

**Table 1: Cross-tabulation: Maths Grade 12 versus MAT1A marks**

MAT1A	Mathematics in Grade 12					Total
	59% or lower	60–69%	70–79%	80–89%	90% or higher	
49% or lower	6	76	69	19	3	173 (48.0%)
50–59%	2	44	50	27	4	127 (35.3%)
60–69%	1	4	15	20	4	44 (12.2%)
70–79%	0	1	1	8	1	11 (3.1%)
80% or higher	0	0	0	2	3	5 (1.4%)
Total	9 (2.5%)	125 (34.7%)	135 (37.5%)	76 (21.1%)	15 (4.2%)	360

Table 1 indicates that 46.4% (167) of the students who scored 60% or more at school scored less than 50% (which is a “fail”) for mathematics at the end of the first year’s first semester. It is more noteworthy that three students who scored 90% or more for Mathematics in Grade 12 failed the subject at university. As already mentioned, the predictive value of school mathematics results is not necessarily credible.

Table 2 presents a cross-tabulation of post-FYS problem-solving and first-year mathematics (MAT1A) scores in various intervals.

Table 2 reveals that 32.5% (117) of the students who scored more than 60% in the post-FYS test obtained less than 50% (i.e. a “fail”) for university mathematics. It seems as if students who scored less than 60% for the post-FYS problem-solving test have a greater probability of not passing the MAT1A course.

A comparison of pre-FYS versus post-FYS problem-solving marks, in accordance with students’ results in MAT1A, is presented in Table 3.

Table 2: Cross-tabulation – post-FYS problem-solving versus MAT1A marks

MAT1A scores	Post-FYS problem-solving scores						Total
	0%	20%	40%	60%	80%	100%	
49% or lower	2	11	43	66	50	1	173 (48.0%)
50–59%	1	2	16	53	52	3	127 (35.3%)
60–69%	0	0	6	10	27	1	44 (12.2%)
70–79%	0	0	0	6	5	0	11 (3.1%)
80% or higher	0	0	0	3	2	0	5 (1.4%)
Total	3 (0.8%)	13 (3.6%)	66 (18.1%)	138 (38.3%)	136 (37.8%)	5 (1.4%)	360

Table 3: Pre- and post-FYS problem-solving scores in accordance with MAT1A marks

MAT1A marks	n	Mean (%) (Pre-FYS problem- solving)	Mean (%) (Post-FYS problem- solving)
49% or lower	173 (48.0%)	39.31	57.92
50–59%	127 (35.3%)	48.73	65.71
60–69%	44 (12.2%)	57.73	71.36
70–79%	11 (3.1%)	50.91	67.27
80% or higher	5 (1.4%)	53.33	73.33

In Table 3, the increase of pre-FYS to post-FYS scores in all five intervals is clear. The mean pre-FYS problem-solving score of the “fail” group (i.e. students who scored less than 50% for MAT1A) improved by 18.6% in the post-FYS test. It can be deduced that students with higher post-problem-solving results have a fair chance of passing MAT1A. Thus, the increase in the mean post-problem-solving results from the pre-solving test results serve as a good predictor of the success or risk of failing MAT1A. Hence, lecturers could apply such results to help identify students who have a strong probability of becoming students at risk (STARs).

The analysis indicates that students with higher post-problem-solving results had a greater probability of passing MAT1A, although many factors could possibly influence the success in MAT1A. The problem-solving module exposed students to what is expected at higher education level, and adds value to understanding success in higher-level mathematics.

### *Concluding comments*

This paper attempted to determine whether there is a relationship between the Faculty's FYS and the performance in Mathematics of its first-year students. It was found that there is definite connection between students' scores on the problem-solving component of the FYS and their achievement in Mathematics in the first semester. Although no causality is implied or can be deduced, first-year students' problem-solving capabilities seem to have substantial predictive value in respect of their performance in Mathematics. This finding elevates the contribution and pertinence of the Faculty's FYS.

The FYS test could increasingly be viewed as a predictive instrument for identifying students at risk of not succeeding. The timing of the FYS (at the beginning of the academic year) has the additional benefit of making available vital information about first-year students in Mathematics, six weeks before first official assessments are conducted. Altogether, then, participation in the FYS must be seen to have a positive influence on students' ability to make a successful transition to university.

The modules of the FYS that focus on mathematical problem-solving, academic language and laboratory skills assist in bridging the current gap between school and university education. Further research along the lines explored in this paper could enable the university, the Science Faculty and first-year students to address transitional challenges much sooner (within the first three weeks of the academic year) by providing appropriate analysis and support where needed so as to ensure first-year academic success.

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