Academic maturity of students in an extended programme in mathematics

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Abstract

This paper focuses on the students who are registered in the University of Pretoria's academic development programme, named the Four-year Programme (FYP). The programme was introduced as a gateway for students who are underprepared but have the potential to succeed and then continue their studies into the mainstream science programmes. Our research focuses on measuring the change in the academic maturity of these students. In the theoretical framework that we developed, academic maturity is subdivided into two components namely non-subject based maturity and subject based maturity (mathematical maturity). This paper focuses on measuring non-subject based academic maturity. The survey used for this purpose is called the Student Academic Readiness Survey (STARS), taken at the beginning of the year and after the first semester respectively. The results of the surveys are compared to measure the change in students' views. Results show that in all constructs there is a surprising decline in students' perceptions regarding their own abilities over the first semester at university. We use the Dunning–Kruger effect to explain this unexpected decline, in that students seem to develop a more realistic view of their own maturity, which in itself can be seen as a growth in academic maturity.

Keywords

Academic development; academic maturity; social maturity; organizational maturity; underpreparedness

1. Background

Academic Development (AD) programmes are becoming standard at universities in South Africa. There is a decline in the number of students qualifying for science and engineering programmes in the country and the main objective with AD programmes is to enable more students to enter into science and engineering (Engelbrecht, Harding, & Potgieter 2015). South African secondary schools are expected to increase the group of learners in these fields irrespective of the challenges they might face (Engelbrecht et al., 2015). The pressure is not only to increase the numbers but to diversify the student population at universities (Jones, Coetzee, Bailey, & Wickham, 2008). This new and diverse cohort brings different types of needs and challenges of the higher education system in the country (Jones et al., 2008).

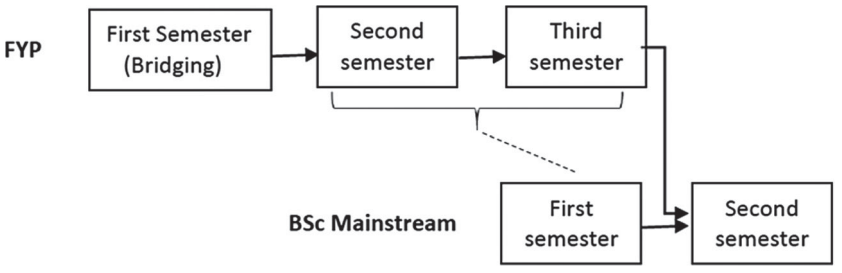

Figure 1. Timeline of the FYP and the BSc mainstream programmes.

The objective of this study is to address the academic maturity of students in mathematics in an AD programme, referred to in this study as an extended programme and named the Four Year Programme (FYP). Because of their unpreparedness in mathematics and science as well as the social change that they are exposed to when entering university, this group of students experiences academic and emotional challenges. For this reason, we attempt to find out to what extent they grow in academic maturity in their first semester at university in the extended programme.

1.1. The four year programme (FYP) at the University of Pretoria

The background to this programme is described extensively in Engelbrecht et al. (2015) and we summarize it here. The programme was initiated in 2008 and has different streams, Agriculture and Biology; Physical Science; Mathematical Science; Information Technology and a commercial BCom stream.

The FYP is open to students with academic potential but whose secondary education did not prepare them adequately for studies at a tertiary level. A large percentage of students admitted are from previously disadvantaged groups. Selection for the FYP is based on students' Grade 12 results combined with the results of an admission test that 'seeks to identify students whose school results do not adequately reflect their potential to succeed with university study, given suitable mediation' (Yeld & Haeck, 1997, p. 7).

Students in the FYP do a first semester of bridging. They then do a two semester programme at a slower pace than the BSc mainstream (their second and third semesters) which is equivalent to the first semester of the BSc mainstream programme. After three semesters they join the BSc mainstream programme for their second semester. See Figure 1.

The strategy of utilizing the FYP to increase the number of contextually disadvantaged students in science programmes is viewed as one of the university's priorities. Financial assistance ranging from full scholarships to partial bursaries is available for the first year of study (two semesters).

2. Literature review

We start the literature review by looking at definitions of academic maturity. Althoff (2010, p. 14), defines academic maturity as

> . . . the tendency to motivate oneself to develop and apply effective strategies in time management, self-discipline, and organisation, and the ability to use these strategies in accordance

with an understanding of one's academic strengths and limitations so as to maximise learning opportunities.

Engelbrecht and Harding, (2006) define academic maturity as the ability to make informed decisions at university and later in life. Academic maturity to these authors encompasses areas such as educational, organizational and social maturity. We are guided by this classification in formulating a theoretical framework.

Althoff (2010), Baker and Siryk (1984) and Pintrich, Smith, Garcia, and Mckeachie (1993) show a strong correlation between academic maturity and academic performance. Althoff (2010) found that although academic maturity emphasizes personal conduct, students with a high level of academic maturity show better academic achievement.

Schunk (2003) maintains that perceived self-efficacy plays an important role in student motivation and learning and affects choice of tasks, effort, persistence, and achievement. At the outset of learning activities, students have goals and a sense of self-efficacy for attaining them.

Perception and hence self-evaluation is used in this study as a measure of academic maturity knowing that this is subjective measure and subject to change over time. Amorose (2012) found in a study set within the physical domain that that most of the students exhibit fluctuations in their self-evaluations. Demo (1992) states that self-concept is susceptible to change as the individual encounters new roles, situations, and life transitions.

The Dunning–Kruger effect (Kruger & Dunning, 1999; Dunning, 2011) refers to a cognitive bias, or illusory superiority, where people with deficits in their knowledge or expertise fail to recognize their lack of ability. In other words, poor performers do not recognize their own shortcomings and over-estimate their proficiency. It is therefore plausible that students who perform poorly at university are necessitated to re-assess their initially perception of own ability.

Students transitioning to university are particularly at risk of bias when self-evaluating. Demo (1992) says that self-concept is more malleable in early adulthood than is later years, due to a more stable environment later on and more time for self-reflection. Mortimer in Demo (1992) maintains that self-concept is stable throughout life, with points of 'disturbance' along the way, of which transitioning to university could be seen as one.

We turn our focus to factors that are considered to impact on academic maturity. Khurshid (2014) identifies five classes of factors that play a vital role in student success, namely students' personal characteristics, institutional support, family support, factors related to students' awareness of available resources at an institution and access to these resources.

Even though intelligence may be identified as a crucial factor that influences academic achievement, there are many other factors (such as time management and goal setting) affecting the academic achievement of students in tertiary institutions. Some of these factors directly affect the progress in a specific subject taught at university (Nayebzadeh, Dehnavi, Nejad, & Sadrabadi, 2013). Once these factors are recognized and the circumstances improved (where possible) the chance of better students' performance increase (Khurshid, 2014).

3. Theoretical framework

What follows is the theoretical framework that we employed to study the factors that impact on students' academic maturity.

The Student Academic Readiness Survey (STARS), developed by Lemmens (2010), featuring prominently in this study, is an instrument used by the University of Pretoria to identify students who are at risk to fail or withdraw from their studies at an early stage in their studies. This instrument evaluates non-cognitive, cognitive and demographic factors (i.e. gender, ethnic group and home environment). Lemmens (2010) was motivated by the problematic national education situation in South Africa, including the limited number of qualifying students, the low throughput and the high attrition rates of students in the system. His objective was to find a relationship between the students' entry features and academic failure.

The STARS questionnaire has 115 items (phrased as statements for agreement to), classified into six dimensions: Motivational factors, Academic involvement, Well-being, Integration and support, Vocational identity and Goal orientation (Lemmens, 2010). Considering that STARS had been used successfully by the university for many years, as an early identification of students who are at risk of failure and withdrawal, we decided to adopt the STARS survey constructs and items for studying the non-subject based maturity part of this study (see the Research Design). The objective of this study is somewhat different to that of the original research using the STARS survey – this study measures the academic maturity of students in an AD programme, while STARS was developed to assess student readiness, and to identify students at risk of not making a success in their university studies. Yet, because of the synonymy of readiness and maturity, readiness is perceived as the first step in the growth process of academic maturity, it made sense to adapt the questionnaire for our purposes.

The Althoff (2010) and Engelbrecht and Harding (2006) definitions have assisted us in classifying behavioural traits into the two dimensions of organizational, social and personal maturity for the non-subject maturity, and into four dimensions of knowing mathematics, doing and reasoning mathematics, representing mathematics and modelling and solving mathematical problems, for the subject-based maturity. In this paper, we focus only on measuring non-subject based maturity.

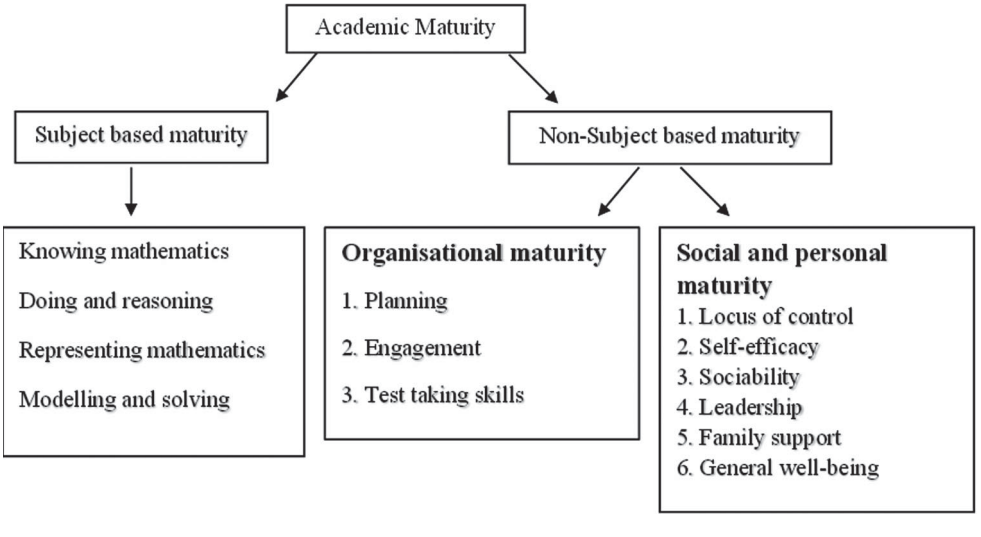

Figure 2. Academic maturity framework.

Adapting the STARS framework for non-subject based maturity, we arrived, through a literature review, at the following framework for academic maturity, used in the study, shown in Figure 2.

For our study, the following working definitions of the constructs in non-subject based academic maturity were adapted from Lemmens (2010).

3.1. Organizational maturity constructs

The construct definitions are given, with example questions given in the results discussion, so as to avoid duplication.

Planning (14 statements): The student's ability to plan her/his studies by setting goals.
Engagement (4 statements): The degree to which a student gets involved with his/her work and lecturers.
Test-taking skills (5 statements): The student's ability to concentrate during a test/examination.

3.2. Personal and social maturity constructs

Locus of control (9 statements): The degree to which a student takes personal responsibility of his/her actions.
Leadership (9 statements): The student's ability to be a leader.
Family support (5 statements): The degree to which a student receives support from his/her family during his/her studies.
Sociability (3 statements): The degree to which a student is able to socialize with others, e.g. fellow students, lecturers, different ethnic groups.
General well-being (5 statements): The student's perception of his/her emotional and physical health.
Self-efficacy (6 statements): The student's ability to achieve his/her academic goals.

From the nine constructs in non-subject based academic maturity in the framework, we identified five constructs as explicitly impacting on academic performance. These are *Planning, Locus of control, Self-efficacy, Engagement* and *Test-taking skills*. *Sociability, Leadership, General Well-being* and *Family support* are perceived to implicitly impact on academic achievement.

4. Research design

The STARS survey was administered to the 2015 cohort of first year students in the FYP during the first-year's university orientation at the start of a new academic year and again during the first week of the second semester. For this study a selection of STARS items were used, and we refer to the reduced STARS survey, administered twice, as the *preSurvey* and the *postSurvey* (see Research Design). We compare the results of the preSurvey and the postSurvey employing a quantitative research design. Responses to negatively formulated items were reversed. In so doing all responses can be viewed as responses to positively formulated items. Agreement to items is then used as a measure of academic maturity.

4.1. Participants

The participants in the study are students registered for the WTW 133 (mathematics module) in the FYP at Mamelodi campus of the University of Pretoria. The module is designed as a bridging module, revising the fundamentals of algebra and trigonometry and gradually introducing new mathematics concepts, such as absolute values. The total course enrolment was 739 and of these students 248 students participated in the preSurvey and 217 in the postSurvey, of which 202 students participated in both the surveys. We study the change in non-subject based academic maturity of these 202 students.

For linking academic performance and non-subject based academic maturity we look at a smaller subgroup of students. There were 124 students who participated in both the STARS and the mathematics examination (used for measuring the subject-based maturity). We divided these 124 students into three groups according to their WTW 133 final examination mark (more detailed information on this grouping is discussed in the Results section) and studied the non-subject based academic maturity per performance group.

The STARS items: From the 115 STARS survey items, 60 were selected and used for this study. These items were grouped into the nine constructs (see Figure 1). Items in the STARS questionnaire involving biographical information, financial support and institutional support, for example were omitted as they do not apply to this study. Other items that do not comply to the theoretical framework were omitted, also paying heed to curbing the length of the survey. Since averages of responses were used, the five point Likert scale was converted to a continuous scale as follows: Strongly Disagree corresponds to the range $1 \leq x < 2$ Disagree to $2 \leq x < 3$, Agree to $3 \leq x < 4$ and Strongly Agree to $4 \leq x < 5$. A further grouping is to refer to two the lower categories collectively as the Disagree category and the upper two categories as the Agree category.

4.2. Data analysis

The data analysis was conducted using the SAS statistical software package. Descriptive statistics, which were used to explore the data, included the frequency, mean and the correlation p-values between the preSurvey and the postSurvey.

Although the Cronbach alpha coefficient was calculated for the STARS survey, it was again calculated for the reduced survey. The coefficient of 0.8890 suggests that the items have relatively high internal consistency and ensures reliability. We subjectively judge the items to be covering the concepts it purports to measure and hence revert to face validity.

A paired t-test with the Kendall tau coefficient (ranging between -1 and 1) is used to determine the correlation between the pre- and postSurvey responses in the different constructs.

5. Results

According to our theoretical framework, non-subject based academic maturity consists of two dimensions with constructs listed under each. The first dimension involves *Organizational maturity* with the following constructs listed under it: Planning, Engagement and Test-taking skills. The second dimension involves *Social and personal maturity* with the following constructs listed under it: Locus of control, Self-efficacy, Leadership, Family support, Sociability and General well-being (Refer to Figure 1).

Table 1. Kendall's tau and *p*-values for the constructs.

	Construct	Kendall's tau	*p*-value
Organizational Maturity	Planning	0.4532	< 0.0001
	Engagement	0.1242	0.0596
	Test-taking skills	0.3802	< 0.0001
Social and Personal Maturity	Locus of control	0.4476	< 0.0001
	Self-Efficacy	0.4536	< 0.0001
	Sociability	0.3919	< 0.0001
	Leadership	0.2614	< 0.0001
	Family Support	0.4308	< 0.0001
	General Well-being	0.4017	< 0.0001

Table 2. Student agreement with survey statements per construct.

	Construct	preSurvey	postSurvey	% Decline
Organizational Maturity	Planning (14)	194	185	4.6%
	Engagement (4)	184	153	16.8%
	Test-taking skills (5)	160	130	18.8%
Personal and Social Maturity	Locus of control (9)	200	198	1%
	Self-efficacy (9)	182	171	6.0%
	Sociability (5)	183	155	15.3%
	Leadership (3)	161	84	47.8%
	Family support (5)	196	170	15.3%
	General well-being (6)	189	146	22.7%

Correlation between the preSurvey and the postSurveyOrganisational maturity: The statistical results in Table 1 show a moderate relationship between the preSurvey and postSurvey results for the Planning and the Test-taking skills constructs, with Kendall's tau coefficient values of 0.4532 and 0.3802, respectively, and a *p*-value of less than 0.0001. On the other hand, Kendall's tau coefficient for the Engagement construct is 0.1242 with a p-value $= 0.0596$ which indicates a poor relationship between the preSurvey and postSurvey results.

Personal and social maturity: Statistical results for five of these constructs (Locus of control, Self-efficacy, Sociability, Family support and General well-being) show a moderate correlation between the preSurvey and postSurvey, with the Kendall tau coefficient ranging between 0.3919 and 0.4536. There is a weaker correlation for the Leadership construct, with Kendall's tau coefficient of 0.2614. All *p*-values are less than 0.0001.

5.1. Overall constructs results

In general, there is a decline in the number of students who choose to agree with the statements, in every construct, in the postSurvey as compared to the preSurvey, as shown in Table 2. For every student an average response mark per construct (over the items in the construct) was calculated. If this average response mark for a student fell in the agree category (between 3 and 5) the student was seen to agree with statements in the construct. The number of statements per construct is given in brackets.

Under Organizational maturity the constructs Engagement (16.8%) and Test-taking skills (18.8%) show the biggest decline, whereas Planning (4.6%) does not show a sizable decline. For Personal and Social Maturity the biggest decline is shown for Leadership

Table 3. Agreement with sample statements from each construct of organizational maturity.

Construct	Statement	preSurvey	postSurvey
Planning	69. I plan my study sessions in advance and pretty much stick to the plan.	175	156
	22. Marks are ideal goals to work towards.	195	176
Test-taking skills	59. I understand all questions asked during an exam.	184	161
	48. During an exam, I'm able to concentrate and keep my thoughts well organized.	191	175
Engagement	38. I will have extensive support from my lecturers during my first year.	112	160
	3. I expect to devote a great deal of time to studying.	201	195

(47.8%), followed by General well-being (22.7%). The large decline in the Leadership construct is reflected upon in the discussion section. Family support and Sociability (both 15.3%) show noticeable decline whereas Self-efficacy (6.0%) and Locus of Control (1%) do not show a sizable decline.

We next look at results for sample items under each construct.

5.2. Organizational maturity

In this section, we take a closer look at sample statements from each construct and the preSurvey and postSurvey results per statement. The purpose is to give the reader more insight in the nature of the statements, also giving an opportunity for discussion on statement level. It should be noted that a few statements are included where there is an increase in agreement in order to give a representative view. We first look at sample statements in Organizational Maturity in Table 3.

The only statement listed in which an increase is observed refers to the extensive support expected from lecturers, which bears positively on the system.

5.3. Personal and social maturity

Table 4 shows example statements of Personal and Social Maturity. Four of these sample statements show an increase in agreement, which is against the general trend but offers an indication of what aspects students feel more positive about. Students feel that people recognize what they do, they are convinced of succeeding, the importance of friends are recognized more as well as the support of family.

6. Comparing results of students grouped according to academic performance

In this section, we classify students into three groups, according to their final mark obtained in the compulsory mathematics module. Students who obtained a mark of 65% and above are referred to as the *good performing* students (26 in total), those who obtained a mark from 50% to 64% are referred to as the *middling performing* students (59 in total), students who obtained a mark of 49% and below are referred to as *poor performing* (39 in total). We consider these students' views on five constructs identified in our theoretical framework as impacting explicitly on academic achievement *namely* Planning, Locus of control, Self-efficacy, Engagement and Test-taking skills. In Figures 3–7 the vertical axes represents the

Table 4. Number of students agreeing with sample statements from each construct of personal and social maturity.

Construct	Statement	PreSurvey	PostSurvey
Locus of control	46. People recognize what I do.	114	124
	57: I take responsibility for my own academic success.	196	195
Self-efficacy	16: I can easily adjust to different styles of teaching.	181	166
	18: I know I am capable of succeeding at university.	157	186
Sociability	51: I expect to become involved in organized student activities.	191	93
	61: My friends are important to me.	185	192
Leadership	9: I would like to occupy a leadership position.	72	21
	20: Other people think of me as a leader.	166	182
Family support	39: My family is a source of my encouragement and support.	179	194
	52: If I run into problems at university, I have someone who would help me.	186	160
General Well-being	35: I feel comfortable with myself.	197	193
	73: I have been able to handle stress over the last month	181	131

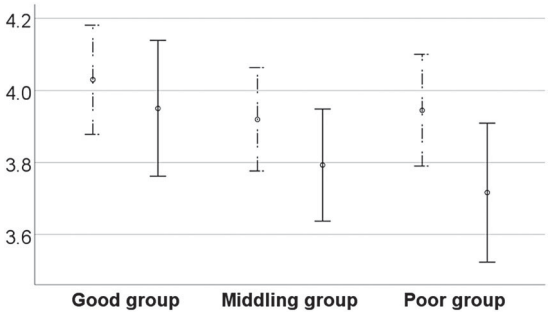

Figure 3. Comparison per achievement group for planning.

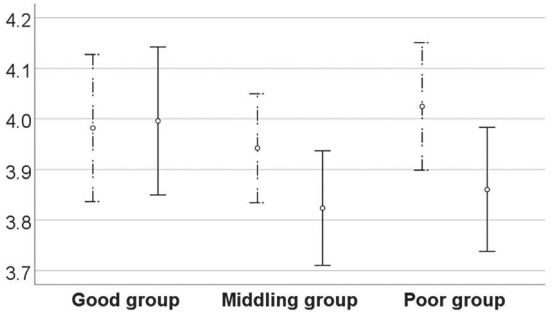

Figure 4. Comparison per achievement group for locus of control.

average score of responses. The dashed lines represent scores of the preSurvey and the solid lines the scores of the postSurvey. Calculations were done with a 95% confidence index.

Figures 3 and 4 represent students' pre- and postSurvey scores for the Planning and Locus of control constructs, respectively. Although the differences are small it appears that the poor performing group shows a larger decrease in agreement compared to the other

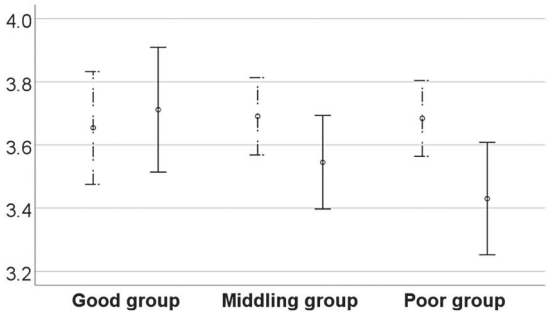

Figure 5. Comparison per achievement group for engagement.

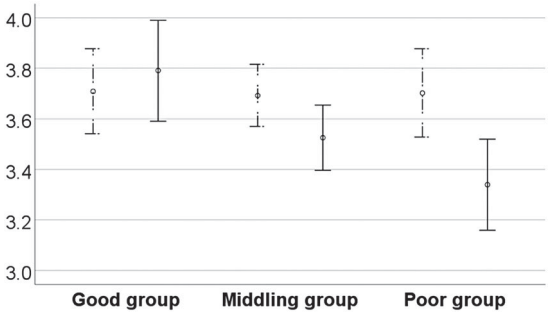

Figure 6. Comparison per achievement group for self-efficacy.

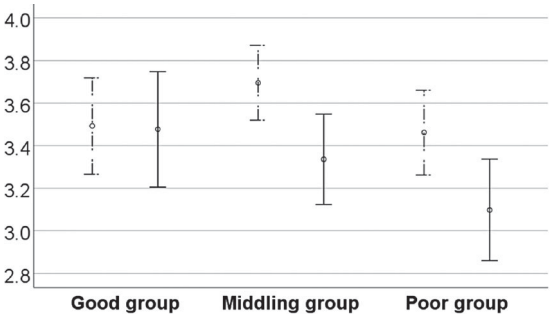

Figure 7. Comparison per achievement group for test-taking skills.

groups. This is a pattern that is observed also for Locus of Control and for the other three constructs as well.

Students' pre- and postSurvey scores for Self-efficacy are represented in Figure 5 and for Engagement in Figure 6. For these two constructs, the good students' scores are higher in the postSurvey compared to the preSurvey, while those of the middling and poor performing students are lower in the postSurvey compared to the preSurvey scores.

Figure 7 represents the students' pre- and postSurvey scores for Test-taking skills. As in the previous comparisons, the middling and poor students' preSurvey scores are higher than the postSurvey scores for this construct.

7. Discussion and conclusion

A period of six months elapsed between the preSurvey and the postSurvey, a period during which participants transitioned from being secondary school learners to being university students. It is commonly considered to be a turbulent time for students in which aspirations do not necessarily transform into reality. During the transition students 'navigate increasingly adult roles, take on new academic and economic responsibilities, and forge new social networks' Amorose (2012).

What did come as a surprise is the general decrease in agreement with the statements set out in the twice-administered survey. The survey was originally aimed at determining the readiness of students for university and now adapted and used for determining what we term the *academic maturity* of students. So how does this finding impact on the non-subject based academic maturity of these students?

By looking at results of different constructs and statements a picture emerges of students who are more realistic in their perceptions of university studies and therefore have a more sober and mature outlook.

Both Organizational maturity and Personal and Social Maturity show decreases in agreement in all constructs, with the biggest decreases occurring in the Leadership Test-taking skills and General well-being constructs. Particular statements where decreases occur are for example:

I would like to occupy a leadership position. (Leadership)

I understand all questions asked during the exam. (Test taking skills)

The conclusion is that whereas at school a leadership position was feasible and it was perhaps possible to understand all questions during the exam, students realize that this may no longer be the case at university.

The constructs of Engagement, Sociability and General Well-being also show substantial decreases in agreement from the pre- to the postSurvey. Statements where there is a decline in the agreement are for example:

I expect to devote a great deal of time to studying. (Engagement)

I expect to become involved in organised student activities. (Sociability)

I have been able to handle stress over the last month. (General Well-being)

It appears that upon entering university, students perceive the environment as structured to suit them, where study sessions are easy to adhere to and there is ample time for studying as well as for organized student activities. These perceptions are adjusted after experiencing university life. Of concern is that students seem to handle stress less and report a decline in their general well-being.

A noteworthy finding is that small decreases occur in the Planning, Locus of control and Self-efficacy constructs, overall, and increases in a number of statements in particular. For example:

I set specific goals before I begin learning for tests/exams. (Planning)

I know I am capable of succeeding at university (Self-efficacy)

People recognise what I do. (Locus of control)

This finding leads to the positive conclusion that students do not seem to have lost their sense of self or confidence in pursuing their studies. This finding then supports Schunk (2003) in his thinking that perceived self-efficacy affects the choice of tasks, effort, persistence and achievement.

Statements related to Family Support in which the agreement has increased underline the increased awareness of the importance and value of friends and family as well as a sustained positive outlook:

My family is a source of encouragement and support. (Family support)

My friends are important to me. (Sociability)

The finding of general decline in the number of agreements with the statements needs elaboration. On identifying three performance groups of students, results on five constructs show a higher decline in agreement with the statements for the middling and poor performing groups than the high performing group.

The Dunning–Kruger effect (Kruger & Dunning, 1999; Dunning, 2011) offers a possible explanation for this finding. Students who are under prepared do not necessarily recognize their own shortcomings and over-estimate their proficiency. The findings also correspond to Demo's (1992) premise that self-concept is malleable in early adulthood and Mortimer's idea (in Demo (1992)) of points of 'disturbance' in self-concept, of which a major change such as embarking on university studies could be seen as one.

The goals with which students enter university could be idealized and over time need to be adjusted. Schunk (2003) states that people are likely to compare their achievement based on the goals they have set at the beginning, that is, when self-evaluation is administered at two separate intervals (where there is a before and after) it is common that people will change their views during the second assessment using the goals they set during the before of a certain event.

In summary: The study set out to determine whether there was growth in the academic maturity of students over the first six months of an extended programme. The instrument used was an extract of the STARS questionnaire, adjusted according to the theoretical framework. Results point to students experiencing this period as an awakening process, a period of aligning perceptions with reality.

Disclosure statement

No potential conflict of interest was reported by the authors.

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