Cognitive and learning styles of the Faculty of Engineering and Technology students: University of Botswana

Oanthata J. Sealetsa & Richie Moalosi

University of Botswana
Gaborone, Botswana

ABSTRACT: This study was conducted to determine whether University of Botswana admissions criteria and students learning styles were predictors of academic performance and degree completion at the Faculty of Engineering and Technology. Field dependence/field independence is a dimension of cognitive style that influences students learning styles. The Group Embedded Figures Test was administered to 77 University of Botswana second year engineering and technology students. The students' Grade Point Average score and the Group Embedded Figures Test were used for analysis to determine students' achievement scores against their cognitive learning styles. SPSS was used in the analysis stage. The results indicate that the Faculty of Engineering and Technology attracts the right calibre of students as the majority of them were highly field independent (analytic), but their academic performance in terms of the Grade Point Average was rather moderate due to a number of factors, such as lack of motivation.

INTRODUCTION

The way people learn and deal with problems largely depends upon the link between personality and cognition. This link is called cognitive styles. Cognitive styles can be described as the manner in which information is acquired and processed by the brain. There are many cognitive styles, such as spatial visualisation, sequential or parallel processing, hemispheral lateralisation (left versus right brain). This study is focussed on one such cognitive style being field dependence/field independence. The Group Embedded Figures Test (GEFT) was administered at the University of Botswana to second year engineering and design students to determine whether they are field dependent (FD) or field independent (FI).

The FD/FI is more related to the process of learning than the aptitude for learning. This aspect is important because students are expected to apply higher cognitive skills, such as collecting, analysing, evaluating, summarising and synthesising information. The categorisation of learners was then mapped against their end of semester Grade Point Average (GPA) to determine their cognitive style's influence on their academic achievement. Research has shown that cognitive skills are an important indicator of success [1]. The overall foci of the study were to determine a potential indicator of success in an engineering and technology faculty, to improve curriculum and instruction.

THEORETICAL FRAMEWORK

Human cognition including cognitive styles is highly relevant to many educational concerns involving teaching and learning [2]. The aforementioned researchers opined that cognitive styles and learning are so important that they may hold important implications for education in general. Cognitive styles represent the core elements of the teaching and learning process as they influence the academic achievement of learners. Cognitive styles describe the information processing habits representing the learner's typical mode of perceiving, thinking, problem-solving and remembering [2].

Most studies in cognitive styles are based on the widely researched Herman Witkin's field dependence model. This model uses the GEFT to assess whether a learner is a field independent (analytical thinker) or field dependent (global thinker). FD learners process information globally. These learners are less analytical and they do not pay much attention to details and view the perceptual field as a whole [3][4]. Learners have a tendency to resist analysis or decomposition. FD learners use social frames of reference to determine their own attitudes, feelings and beliefs [3]. They prefer group projects and need more assistance from the educator.

On the other hand, FI learners are highly analytical in perceiving and processing information. They can easily break the field down into its component parts. These learners are not influenced by the existing structure and can make choices

independent of the perceptual field. These learners exhibit a tendency to organise information into manageable units and appear to possess a greater capacity for retention of information [2][5][6]. They prefer situations that allow them freedom in working towards their goal and solving problems, as well as working individually. The characteristics of FD and FI can be summarised as shown in Table 1 with regard to teaching styles [7].

Table 1: Teaching styles of field dependent and field independent learners.

Teaching Styles	
Field Dependent	Field Independent
Prefers teaching situations that allow interaction and discussion with other learners.	Prefers impersonal teaching situations such as lectures. Emphasise cognitive aspects of instruction.
Uses questions to check on student learning following instruction.	Uses questions to introduce topics and following learner answers.
Uses learner-centred activities.	Uses a teacher-organised learning situation.
Viewed by learners as teaching facts.	Viewed by learners as encouraging the application of principles.
Provides less feedback, avoids negative evaluation.	Gives corrective feedback, uses negative evaluation.
Strong in establishing a warm and personal learning environment.	Strong in organising and guiding student learning.

It is imperative for educators to recognise students' learning styles because using this information will help them meet their learners' individual needs and capabilities effectively through the application of appropriate responsive teaching styles. These styles are an essential indicator of success in an educational environment. Therefore, educators need to balance their teaching styles so that they may cater for both groups of learners. Understanding of student individual differences presents such an opportunity.

Research has shown that engineering and accounting courses tend to attract students who exhibit concentration and analytical skills [2][8][9]. For example, Murphy, H.J. et al investigated a group of 89 undergraduate students from a cross section of business courses using the GEFT and found them to be moderately FI [8]. Another study also investigated cognitive styles patterns among students in engineering courses and related differences in the academic performance of those students [2]. The impetus of this study involved the concerns among engineering educators with regard to the difficulty students experienced in the programmes provided. In this study, students categorised as middle and analytic scored significantly high on the end of course examinations.

The GEFT measures problem-solving and analytical abilities, such as those necessary for engineering and accounting careers [9-11]. The ability to *pull out* a specified object from a given background is a necessary trait for individuals interested in engineering careers [10]. Despite several studies conducted globally on cognitive styles and learning using the GEFT, few of those explain the cognitive abilities in the context of African university students.

RELATIONSHIP BETWEEN TEACHING STYLES AND LEARNING STYLES

The relationship between the cognitive style and learning performance is based on the premise that both the educator and students should be knowledgeable about their styles so that they can consciously adjust, adapt or modify them in order to increase learning. The first step in reaching this goal is to make a personal assessment of one's own learning and teaching style. The educator's learning style has an effect on his/her teaching style. Kollofell observes that individuals tend to teach the way they learn, unless there is a conscious reason not to [12].

The more educators learn about their own teaching style, the more they can explain what happens in their classroom and why. By making explicit their teaching and learning style, the educators have taken a step towards realising that not all of their students learn as they do and perhaps some problems students might have, such as lack of motivation are a result of the mismatch between their teaching and students' learning styles. Once educators gain an appreciation of the variety of learning styles, they can respect learning styles differences and adapt their teaching styles for different situations.

Learning styles are critically important in laying the groundwork for understanding students' learning performance [13][14]. This provides educators with an opportunity to be alert to situations in which students' learning styles limit their success in academic areas. Teaching and learning style matches have been found to increase satisfaction and mutual regard among educators and students and mismatches can be detrimental to affective style aspects, producing anger, frustration, unruly behaviour, procrastination and even major emotional problems [15].

USE OF MEDIA IN TEACHING AND LEARNING

The search for a better solution to teaching and learning should be a challenge to every educator. Research has shown that if media are used properly and in the right place, they can contribute to purposeful teaching and learning [16]. In order to overcome some of the aforesaid issues, the dramatic growth of social media creates new opportunities for engaging students. An e-learning environment provides flexibility for students to learn across different times and

locations, allows self-paced learning and provides a non-traditional learning alternative [17][18]. These include social networking sites, such as Facebook, MySpace, LinkedIn and Twitter along with blogs. These types of media are rapidly changing the way people interact with one another, and it challenges the way teaching and learning has previously been done. Social media can be used as an effective teaching tool as it is changing teaching and allowing different learning practices. These media require that the educator step outside of the traditional lecture method and facilitate learning by encouraging students to learn through the media. Studies have shown that using media makes programmes more relevant to students, increases attention, motivation, confidence, satisfaction, class attendance and raises examination scores [19]. Social media are good for cognitive reasoning as they provide the opportunity for students to practice all the six Blooms cognitive domains of recall, comprehension, application, analysis, synthesis and evaluation.

In research conducted by the Educause Centre for Applied Research, Dahlstrom, E. et al report that more than 30% of students said they use sites, such as Twitter, My Space, LinkedIn and Google+ and they wished their educators could incorporate these sites into the curriculum more often [20]. The survey also indicated that students preferred using e-mail, learning management systems and e-books and they want their educators to use these media more frequently. Even though these technologies are available to most universities, some students felt that their educators do not use them effectively or that they do not have the skills to use them effectively.

Research also shows that there are a number of barriers to accepting the use of technology in teaching, including time, resources, both financial and physical, as well as lack of training and institutional support. These are the most significant barriers to accepting the use of technology in teaching [21]. Furthermore, Al-Senaidi, S. et al indicate that there is resistance to change which prevents full integration of information communication technology in the classroom, as well as negative attitude to accepting new technology and lack of confidence [21].

HYPOTHESIS

Field independence is thought of as a necessary trait requisite for individuals interested in engineering-related careers [10][11]. Therefore, the main interest was to investigate whether or not the Faculty of Engineering and Technology is able to attract students with the required traits. The hypotheses of the study were as follows:

1. There is a strong relationship between scoring high on the GEFT and obtaining a high GPA;
2. Students with high GPAs will score high on the GEFT;
3. Students in the Faculty of Engineering and Technology are more FI than FD;
4. Male students are more FI than female students;
5. The GEFT can be used to identify students with the superior problem-solving and analytical skills requisite for engineering and technology careers.

RESEARCH METHOD

A survey which involved 77 undergraduate second year students in the Faculty of Engineering and Technology of the University of Botswana was undertaken. Of these students 57 (74%) were male, while the remaining 20 (26%) were females. The study covered students from seven programmes offered by four departments namely; Civil Engineering, Electrical Engineering, Industrial Design and Technology and the Department of Mechanical Engineering. The programmes the study covered were construction management, design and technology, industrial design, industrial engineering, electrical engineering and mechanical engineering.

A survey was used for the study because the hypothesis required an explanation of the relationship between variables. Quantitative research is used where the hypothesis can best be answered by a study in which the researcher seeks to establish the overall tendency of responses from individuals and note how this tendency varies among participants [22]. By studying a representative sample of participants, the survey approach seeks to discover relationships that are common across participants and, hence, to provide generalisable statements about the object of study. Surveys can accurately document the norm, identify extreme outcomes and delineate associations between variables in a sample. The interest of the authors was to find out whether one or more variables might influence another variable.

After the survey phase, qualitative in-depth interviews with ten purposive sampled students across all departments were conducted to unearth some of the underlying reasons for some responses. This method was found suitable for this phase because describing a trend means that the research problem can best be answered by a study in which the researcher seeks to establish the overall tendency of responses from individuals and to note how this tendency varies among people [22]. The study can inform the researchers about how the student population views an issue under investigation and how diverse their views are about the issue.

The Group Embedded Figures Test (GEFT) was used to collect information on students' cognitive styles. GEFT is a perceptual test, which requires participants to locate a previously seen figure within a large complex figure [23]. There are three sections to this instrument. Section 1 is a two minutes practice session, which is composed of seven easy figures to be located. Sections 2 and 3 both contain nine items each, which need to be completed in 30 minutes. An item is deemed correct if the simple item is correctly outlined within the complex figure [10]. Scoring is based on the number

of simple figures correctly traced and may range from 0 - 25. Students who obtain a high score (18 - 25) are described as being Analytic or FI. Average scorers are referred to as Middle (10 - 17), while those scoring low (0 - 9) are described as being Global or FD. Most research on the GEFT has been generally supportive of its psychometric properties [2][8-11]. Therefore, for this study the authors considered that GEFT was adequate to assess students' cognitive styles. Furthermore, semester 1 and 2 students' Grade Point Averages (GPA) were used as a measure of students' achievement.

To determine students cognitive styles, the GEFT scores were used and coded into three categories namely 1 = Not Analytical/Global (score from 0 - 9), 2 = Average/Middle (scores from 10 - 17), and 3 = Analytical (score from 18 - 25). This coding is premised on the general interpretation of the standard distribution curve, where most individuals are expected to be somewhere in the middle exhibiting both cognitive styles, while individuals on the two extremes ends are expected to exhibit traits congruent with those espoused by the theory of FD and FI. This standard coding was also used by eminent scholars such as Clark et al [10]. In this regard, the basic descriptive statistics were relevant to illustrate frequency distribution of students by cognitive ability.

To determine student performance, the average GPAs from semester 1 and 2 were computed and coded into two categories namely high (3.5 to 5), and low (0 to 3.49). Thereafter, these were cross tabulated with GEFT to determine the proportion by gender and correlation between GEFT scores and GPA scores. The Spearman's Rho (r) was, then, used to establish correlation between the variables. Finally, the authors attempted to ascertain whether the GEFT can be used as a tool to identify students with superior problem-solving and analytical skills that are requisite skills needed in engineering and technology careers. In this regard, the mean of the total scores on the GEFT was used. The Statistic Package for Social Scientists (SPSS) was used for analysing the data.

RESULTS

GPA scores: The GPA scores showed a mean value of 3.13 and a standard deviation 0.76. Fifty-nine students (76.6%) had a low GPA, while 18 (23.4%) had a high GPA suggesting that students' performance at the Faculty of Engineering and Technology was moderate. The low GPAs were found among female students. For example, only two female students out of a total of 20 (10%) scored a GPA of above 3.74 compared with 17.5% of male students. This indicates perhaps that gender was a determinant factor of success. However, this is consistent with other studies conducted by O'Brien et al [2], where it was shown that male students in engineering education outperform their female counterparts.

The results further indicate that 96% of the students have had a declining GPA from the first to the second semester. If the Faculty is attracting the right students, what could be the causes of such a decline? In this regard, there was a need to investigate further some of the reasons, which contribute to this scenario. The investigation indicated that participants advanced several reasons, which ranged from lack of motivation, excessive workload, use of appropriate teaching media and negative attitude to learning.

Lack of motivation: Lack of motivation was cited as one reason why students' GPA declined. Participants indicated that the following are some of the reasons, which lead to lack of motivation:

Materials have little relevance to the professional growth...
Some courses are irrelevant to my career development because there do not stipulate how they will help me in the future.

There is lack of motivation hence students lose interest...

Use of inappropriate teaching media: The commonly used teaching media in the Faculty include e-learning packages (Blackboard and Moodle), PowerPoint, video and video conference. Participants pointed out that using inappropriate teaching media also contribute to lack of motivation to learn and, hence, the decline of the GPA. Participants stated that:

Some lecturers are not using innovative teaching media in their course delivery.
Our lecturers are not using the Facebook and Twitter in teaching.
The traditional teaching methods used make us get bored and lose interest in the course.
It de-motivates me in attending my lectures because the material presented is already posted in Blackboard.

The last point requires that lecturers should be careful when posting and giving access to students using Blackboard. It would be advisable for students to get access to the material that has already been covered. Students can then use the same for revision purposes or as reference material.

Too high a workload: Some participants indicated that too high a workload from their different programmes of study also contributed to their declining GPA. For example, these participants expressed that:

My programme has too high a workload.
There is a lot of work for very few credits thus affecting my motivation to learn.

There is always an assignment to submit or a test to write, this does not give us time to learn for the improvement and growth of our skills.

GEFT scores: In contrast, the GEFT scores indicated a mean value of 19.2 and standard deviation of 5.68. In total, four students (5.2%) were *not analytic,* while those regarded as *average* accounted for 20.8% (16 students). There were 57 analytic students (74%). This indicates that the majority of students at the Faculty are analytic and, as such, possess the requisite traits for engineering and technology careers. This is consistent with other studies conducted elsewhere on engineering and technology students' analytic learning abilities [10]. However, in this study, the high score on the GEFT did not necessarily reflect high GPA as was expected.

Correlation: A Spearman's Rank Order Correlation was run to determine whether a relationship between GEFT scores and GPA scores existed. The results of this analysis revealed that there was a positive correlation between GEFT and GPA scores ($r = 0.276$). However, this correlation was not statistically significant.

DISCUSSION AND CONCLUSIONS

The GEFT scores suggest that the Faculty of Engineering and Technology attracts students with analytical skills of which many researchers imply are traits essential for an engineering career (Mean score 17.5 in the GEFT scale out of a total of 25). On the other hand, it is clear that the same students have generally low average GPA (3.13), contrary to the expectation of 3.5 - 5. This scenario raises one fundamental question, that is; why are students at this Faculty not performing satisfactorily despite having the right traits for engineering and technology careers. In the qualitative in-depth interviews, students advanced the following as reasons, which led to a decline in their academic performance. These were; lack of motivation, too much work, attitude towards learning and the use of inappropriate teaching media.

The educator's ability to use appropriate media for teaching and learning plays a pivotal role in this instance. Research shows that most of today's educators are not at the same communicative level with students because university students are reported to be taking social media to a new level through the use of Web sites, such as Facebook, Twitter and LinkedIn. Most educators are perhaps unable to cope with these new challenges. The use of social media facilitates learning to take place beyond time prearranged for lectures. Facebook and Twitter offer an opportunity to connect with students outside of the classroom in a way that is unprecedented [24]. These media allow real-time collaboration and everyday teaching and learning. In this study, students reported that their educators are not yet in a position to embrace social media in learning and teaching.

The use of social media encourages collaboration, creativity and mastery of ideas and concepts. This approach also encourages non-linear learning. Interaction using social media provides students with a sense of belonging and creates bonds between the students and their peers, and between students and the educator [12]. Social media can be used as an effective teaching tool and it has the following advantages:

- Increasing learning motivation - lecturing is the least effective method of student learning. Social media allow students to be more motivated because they participate in the learning activity. For example, showing a video or a virtual field trip allows students to view it in their own time and reflect on the presentation before they respond. The reflection time may produce a more complete understanding of the content. Technology can make learning a more immersed, engaging and relevant experience [20].
- Collaborative learning - collaboration is a common feature because the educator, students and peers rely on other experts or professionals to present current accurate content, unique material and links for teaching and learning. These professionals will provide more complete information than the educator alone. Discussion groups can be created for class projects or tweet about a concept and the educator can keep track of students' participation, provide guidance and monitor progress.
- Location and timing of learning - when links to resources, assignments are available, students will not be tied to location or a time schedule for learning [18]. This allows students held up to read and understand content that they will respond to outside of the physical classroom. The students become more independent.
- Increased communication - the flow of information is enhanced since students get to practice the written communication skills they will regularly use in the world of text communication. Furthermore, the communication is no longer coming from the educator to students but a two-way communication link is established. Social media allow the posting of reminders, upcoming events, schedules changes, posting of documents for easy access to students. Technology helps students feel connected [20].

Therefore, educators need to make better use of technologies that students value and this can easily be integrated into their learning experiences. These technologies should be used in a more transformative ways, such as participatory and collaborative interactions, and for high level teaching and learning that is engaging and relevant to students lives and future professional development. Educators need to move strategically toward blended/hybrid learning environments to meet students' preferred styles of learning. They should offer many different ways for students to engage in learning to use technology and to meet differentiated needs. Perhaps doing so will address the declining student performance and the issues students raised.

In this study, the authors appreciated that FD and FI students tend to favour different learning approaches. The learning approach favoured by one kind of a student might simply not work for another student. In addition, whether one approach will lead to better learning outcomes than the others seems to depend on three fundamental aspects. These are: the specific characteristics of the learning tasks, the particular circumstances of the learning tasks and the particular circumstances under which learning takes place. Therefore, it is not unreasonable to assume that educators should be aware of the ways in which FD and FI students learn concepts. This is so because such awareness can assist educators to become more effective in adapting and aligning instructional procedures to the needs of these different kinds of learners. Educators may also find ways of helping students diversify their learning strategies. The Faculty of Engineering and Technology at the University of Botswana attracts students with appropriate traits for engineering and technology careers. However, it is evident that though students' have the suitable traits, their GPAs are far from reflecting that 96% of the students have had a declining GPA since first semester and this is a great concern for the Faculty.

REFERENCES

1. Altun, A. and Cakan, M., Undergraduate students' academic achievement, field dependent/independent cognitive styles and attitudes towards computers. *Educational Technol. & Society,* 9, **1**, 289-297 (2006).
2. O'Brien, T.P., Bulter, S.M. and Bernold, L.E., Group Embedded Figures Test and academic achievement in engineering education. *Inter. J. of Engng. Educ.*, 17, **1**, 89-92 (2001).
3. Ruttun, R., The effects of visual elements and cognitive styles on students' learning in hypermedia environment. *World Academy of Science, Engng. and Technol.,* 49, 963-971 (2009).
4. Chan, L.J., Applying motivational analysis in a wed-based course. *Innovation in Educ. and Teaching Inter. J.,* 46, **1**, 91-103 (2009).
5. Garton, B.L., Spain, J.N., Lamberson, W.R. and Spiers, D.E., Learning styles, teaching performance, and student achievement: a relational study. *J. of Community Devel. Educ.,* 40, **3**, 11-20 (1999).
6. Garton, B.L., Kitchel, T. and Ball, A.L., University admission criteria and learning style: predictors of academic success? (2005), *NACTA J.,* 18 April 2012, www.findarticles.com/p/articles/mi_qa4062/is_200506/ai_n13643624/?tag=content;col1
7. Garger, S. and Guild, P., Learning styles: the crucial differences. *Curriculum Review*, 9-12 (1984).
8. Murphy, H.J., Casey, B., Day, D.A. and Young, J.D., Scores on the Group Embedded Figures Test by undergraduates in information management. *Perceptual and Motor Skills,* 84, 1135-1138 (1997).
9. Jones, S. and Wright, M., The effects of a hypertext learning aid and cognitive style on performance in advanced financial accounting. *Issues in Accounting Educ.,* 25, **1**, 35-58 (2010).
10. Clark, S., Seat, E. and Weber, F., The performance of engineering students on the Group Embedded Figures Test. *Proc. 30th ASEE/IEEE Frontiers in Educ. Conf.*, Kansas City, USA, 18-21 October (2000).
11. Lunt, B.M., Predicting academic success in electronics. *J. of Science Educ. and Technol.*, 5, **3**, 235-240 (1996).
12. Kolloffel, B., Exploring the relationship between visualizer-verbalizer styles and performance with visual or verbal learning material. *Computers & Educ.,* 58, **2**, 697-706 (2012).
13. Furnham, A., Monsen, J. and Ahmetoglu, G., Typical intellectual engagement, big five personality traits, approaches to learning and cognitive ability predictors of academic performance. *British J. of Educational Psychology,* 79, 769-782 (2009).
14. Jackson, C., Baguma, P. and Furnham, A., Predicting grade point average from the hybrid model of learning in personality: consistent findings from Ugandan and Australian students. *Educational Psychology,* 29, **7**, 747-759 (2009).
15. Huang, E.Y., Lin, S.W. and Huang, T.K., What type of learning style leads to online participation in the mixed-mode e-learning environment? A study of software usage instruction. *Computers & Educ.,* 58, **1**, 338-349 (2012).
16. Kallstrom, L., Blogging: five advantages of teaching using a blog (2009), 27 April 2012, www.voices.yahoo.com/blogging-five-advantages-teaching-using-blog-3076890.html
17. Graff, M., Learning from web-based instructional systems and cognitive style. *British J. of Educational Technol.,* 34, **4**, 407-418 (2003).
18. Latham, A., Crockett, K., McLean, D. and Edmonds, B., A conversational intelligent tutoring system to automatically predict learning styles. *Computers & Educ.,* 59, **1**, 95-109 (2012).
19. Medcalfe, S., The relationship between music and student enjoyment of economics class: how to compete with grand theft auto, crack and chlamydia! (2010), *J. of Economics and Economic Educ. Research,* 30 April 2012, www.findarticles.com/p/articles/mi_qa5529/is_3_11/ai_n56345706/?tag=content;col1
20. Dahlstrom, E., de Boor, T., Grunwald, P. and Vockley, M., National Study of Undergraduate Students and Information Technology, 2011 Research Report. Boulder, CO: EDUCAUSE Center for Applied Research, 2 May 2012, www.educause.edu/ecar.
21. Al-Senaidi, S. Lin, L. and Poirot, J., Barriers to adopting technology for teaching and learning in Oman. *Computers & Educ.,* 53, **3**, 575-590 (2009).
22. Creswell, J.W., *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research.* London: Pearson Education, 42-64 (2002).
23. Witkin, H.A., Oltman, P.K., Raskin, E. and Karp, S.A., *Group Embedded Figures Test Manual.* Palo Alto: Consulting Psychologist Press (1971).
24. Wagner, R., Educational technology: social media tools for teaching and learning. *Athletic Training Educ. J.,* 6, **1**, 51-52 (2011).