Creativity and Innovation in Science and Technology—bridging the gap between secondary and tertiary levels of education

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ABSTRACT

This paper focuses on a study conducted with a sample of teachers and students at secondary and tertiary levels with a view to situating whether there is a gap between these two levels of education and, if so, to what extent the gap exists particularly in Science and Technology education. The paper also examines how this impacts upon students’ creativity and innovativeness at university level.

The methodology consists of analysing the current situation in terms of students’ engagement/creativity/innovativeness in Science and Technology at the secondary and tertiary levels. Questionnaires were administered to teachers and students at both levels, while interviews were also conducted to triangulate the data.

The findings and recommendations of the study will be beneficial to various stakeholders who wish to understand the gap existing between secondary and tertiary education in Science and Technology education.

Keywords: innovation, creativity, quality mindset, quality education
1 INTRODUCTION
The decision of the government to offer tertiary education to 100,000 international students by 2020 is indeed a daunting task although not an impossible one. Mauritius, without natural resources, has been struggling hard to keep and maintain a high status in Africa. Our human resources are the key agents which, until now, have been the determining factor to making Mauritius one of the most flourishing economies in Africa. In order to remain competitive in the world arena, our younger generations need to be equipped with dynamic knowledge, new set of skills and values. In this fast changing world, new priorities are being set, which demands new ways of thinking and operation. The Mauritian education system is bound to change to be able to address the requirements of the new technology-savvy generations. The extent to which the secondary and tertiary systems of education brought appropriate adjustments in the way teaching and learning take place is an area that will be investigated in this study. Any changes happening in society will inevitably impact on life processes in society and the search and development of new approaches are part of the normal process of a dynamic society. The charisma and behaviour of leaders, their intelligence and creativity have been moulded by the system of education existing in that particular country.

This paper focusses on a study conducted with a sample of teachers and students at secondary and tertiary levels with a view to situating whether there is a gap between these two levels and, if so, to what extent the gap exists particularly in Science and Technology education. The paper also examines how this impacts upon students’ creativity and innovativeness at university level.

2 THEORETICAL FOUNDATION
The dynamism prevailing within a society depends significantly on the innovativeness of its population as to how the people are creating knowledge that contributes to the welfare of the society (Meek et al, 2009). The school has a crucial role to play in developing in students a critical mind that would allow them to see and interpret things differently and thus be creative. Creativity and innovation are closely intertwined and are the basis of any developments in society.

On one side, innovation can contribute to develop a sense of responsibility in learners in addition to making them become responsible and active citizens (Shapiro et al, 2007). On the other side, creativity which includes ‘assimilators’ and ‘explorers’ (Martinsen, 1995) is essential for the mind to become producers of knowledge (Houtz and Krug, 1995). Creativity
is also seen as the building block for innovation. Innovation without creativity leads to a situation where only technicians are produced and not visionaries. Visionaries are creative people who make things out of nothing (Handy, 1999) but the development of creativity needs to have a social dimension as well as a contextual perspective (Csikszentmihalyi, 1988; Drazin et al., 1999; Beyer, 1984; De Bono, 1983). Vygotsky clearly emphasises on the social dimension in knowledge construction by learners (Daniels, 2001). The interaction in a social set up and the use of language are determining factors (Vygotsky, 1978) in the development of a critical mind. By providing opportunities for learners to express themselves freely and to challenge different points of view, they are able to break down the barriers that exist between disciplines and subject areas (Johansson, 2004).

The social element is the stepping stone towards the development of a critical mind and critical thinking in learners that eventually lead them to innovate. In Mauritius, it is unfortunate to contemplate that although the National Curriculum Framework (2009) highlights an integrated approach to teaching and learning, it is not being put in practice at school. Furthermore, an integrated approach, as clarified by Johansson (2004), is essential in knowledge construction and that rote learning concepts, strategies and procedures is a wasteful undertaking since the working memory has, unfortunately, limited capacity (Tarmizi&Sweller, 1998; Sweller et al., 1990). Sweller (1988), introduces the cognitive load theory to explain how valuable instructional resources can encourage learning during activities that are pertinent to schemata acquisition.

College (Parmessure et al., 2003) and university (Carre, 1981) students are still resorting to rote memorisation to learn concepts in a passive way and this would severely impinge on their abilities to develop creativity and eventually become innovators. The development of a critical mind through critical thinking is the determining factor to creativity and innovativeness. Mauritius has placed higher education as a top priority in a bid to leapfrog into tertiary education – an endeavour to ensure that the island becomes a competitive partner. With a laudable initiative of one graduate per family, a review of the educational systems, at the secondary and tertiary, should be a priority. Such a review is bound to take into consideration the various challenges that Small Island States have been experiencing in secondary and tertiary education and to offer opportunities for the tertiary sector to espouse.

3 METHODS

Participants
The participants in this study were 27 students/trainees (graduates) from three public institutions. The university students came from three different faculties who either are still following the undergraduate course or have completed it. The fields of study of these students were mainly from Information Technology, Food Science, Mathematics and Biology. Three were from the first year while 5 from the 3rd year and the remaining have just completed the undergraduate course. There is a need to point out that from the 30 participants who were invited to participate only 17 responded positively. 10 post-service physics trainee teachers undertaking the Post Graduate Certificate in Education were also involved at a later stage.

Data collection
To explore the students’ views and perceptions about their experiences in secondary schools and at university, surveys and interviews were conducted. Classroom observations were conducted in the secondary schools to gain an insight on how the teachers were implementing their lessons. Comments and reflection about the classroom processes were collected in an observation log. Two semi-structured interviews, which were video recorded, were organised independently with 6 students and 10 trainee post-service teachers undertaking the Post Graduate Certificate in Education Course.

Surveys
A questionnaire was administered to 17 university students. It consisted of 21 questions and participants were invited to provide information on the following broad categories based on their knowledge and experiences:

(a) personal background information
(b) counselling facilities
(c) appreciation of the faculty
(d) choice of subject related to science and technology
(e) understanding of critical mind
(f) motivation to pursue further studies
(g) understanding of innovation
(h) weaknesses of the present educational system

The questionnaire was pilot tested with a sample of three students and minor modifications were brought to items (e) and (f) to relate it to their modules.

Semi-structured Interviews
A focus group of 6 students from the two universities and 10 post-service trainee teachers were interviewed in two different interview sessions. There was no objection to video record the session from both groups. The semi-structured group interview with the university students was deemed necessary only during the analysis of the questionnaire when we were not convinced of the truthfulness of the answers.

The semi-structured interview with the 10 trainee teachers (who voluntarily accepted to participate in the video recorded sessions) was mostly oriented at (a) the strategies they use to teach concepts, (b) the classroom dynamism and (c) their constraints.

4 DATA ANALYSIS & DISCUSSIONS

Students’ Perspectives – Questionnaire & Interview

In order to obtain a better idea about the university students’ experience in secondary school and that at university level, the students’ responses were analysed. Table 1 illustrates the percentage-wise response of the students in relation to five of the six categories. The background information has helped the authors to make the appropriate selection of students for the interview.

<table>
<thead>
<tr>
<th>Assessment categories</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counselling facilities</td>
<td>64.7</td>
</tr>
<tr>
<td>Appreciation for the faculty</td>
<td>87.0</td>
</tr>
<tr>
<td>Choice of subject related to Science/Technology</td>
<td>50.0</td>
</tr>
<tr>
<td>Development of a critical mind</td>
<td>95.0</td>
</tr>
<tr>
<td>Motivation to pursue further studies</td>
<td>82.0</td>
</tr>
</tbody>
</table>

Counselling facilities

It is quite surprising to note that the majority of the students (64.7 %) did not take advantage of the existing career counselling service that the Ministry of Education & Human Resources was offering, though they were aware of the existence of such a service. At the very outset of career identification, the students did not show any interest on what our tertiary institutions were offering to better prepare their entry in the domain of tertiary education. This free counselling service is crucial for helping students to choose the appropriate subjects/course and it serves as a direct link with their future career orientations and also to make wise educational, personal and social decisions (Egbochuku, 2008). During the interview with the
trainee teachers, they confirm that they usually do not advise students about the importance of the counselling service. They felt that it was the responsibility of the parents to advise their kids about counselling programmes on their choice for higher education.

During the interview with the students, four out of six students confirmed that during their secondary schooling they did not find it necessary to attend to such sessions and that they would ‘cross the bridge’ when the time comes. The two students who opted for the service clarified that their choice of subjects depended on what they learnt in those sessions. Most of the teachers also confirmed that they did not advise the students to seek the help of counsellors as they were more preoccupied with their teaching and completing their ‘lessons plans’ for the next day and they felt that such a task was, above all, the parents’ responsibility.

 Appreciation for the faculty
87% of the students emphasized on their appreciation for their respective faculty lecturers. However, during the interview all the students brought out that for them a good lecturer is one who would be ‘spoon feeding’ them as was the case when they were studying in secondary schools. Some of them even expected to be offered support from the laboratory technicians when undertaking work on their dissertations. Such a near rote mode of learning (Novak, 2002) leads to situated cognition (Brown et al., 1989) where the learner is trapped into limited transfer of knowledge, while such an approach is confirmed by Kember (2002) to bring low-academic outcomes. Moreover, business firms in one of the Small Island States (SIDs) claimed that lack of skills and education of workers was a serious obstacle for competitiveness (Martin, 2011) and that the education systems are not preparing graduates sufficiently to enter the job market.

During the interview, the trainee teachers also confirmed their preference for the traditional approach and because of time constraints, which they identified as their main reason; however, they were unable to clearly explain the extent to which time is really a predominant factor in the teaching-learning process.

 Choice of subject related to Science and Technology
In relation to the choice of subject, 50 % of the students selected a Science or Technology course which was not their first choice. During the interview, the students emphasised on the fact that their Higher School Certificate results was the cause for not obtaining the subject of their first choice. This definitely has an adverse effect on the abilities and performances of
students as emphasised by Edwards & Quinter (2011). The choice of the subject becomes one of the demotivating factors in hindering students from being creative and eventually developing an innovative mind. Moreover, during the interview, the students claimed that there is merely any connection between what they have been studying and the world market and that they would wish to have placement in industry and other areas as part of the undergraduate programme. There is a need to highlight that SIDs face a number of salient problems and that partnership between the public and private sectors in relation to tertiary education is an important element (Bray, 2011). The move to connect to the private sector has already started with the inclusion of the *ICT Skill Development Programme* (*Le Matinal*, 2011); however, the need to establish a partnership structure remains a necessary endeavour.

**Development of a critical mind**

The survey shows that 95% of the participants were of the view that they have developed a critical mind during the course of their study but during the interview, both groups of students and trainee teachers related ‘a critical mind’ to grades in examinations/assignments rather than to a way of thinking. The interview with the students also revealed a few surprising facts about rote learning still recurrent among them. Their experiences in the secondary level of education are still very prominent at the tertiary level of education. A critical thinking perspective demands that schools and universities adopt a learner centered approach and this demands a shift in mindsets from both the educators and the students (Raihanah & Mary-Ann, 2010). During the interview, the students highlighted that they had group discussions only when it came to working on their assignments and that they would refrain from giving ample details on certain areas for fear that their friends would pick up their ideas. They also mentioned that they still enjoy being dependent on their parents in terms of waking them up, making their beds or preparing their breakfasts. The students acknowledged that the development of a critical mind demanded that they had to review their mindsets by doing things differently. They also highlighted that they have been learning science and technology modules by rote and that they have now understood the consequences of their action.

We are of the view that the development of a critical mind should not be perceived to happen at school or university but in everything that one does and that critical thinking should be nurtured at all levels to avoid mismatch between acquisition and expectation. The students admitted that during most part of their studies, they were not very confident and they tended to rely mostly on the lecturers. Obviously, Patel (2003) confirms that confidence is one of the
determining factors for students to become independent learners and that they ‘should be encouraged to develop a voice’ (Raihanah & Mary-Ann, 2010, p. 473).

Moreover, during the interview, the students were of the view that although group work is an important component in university programmes, they refrained from engaging themselves in extra-curricular activities which required group involvement. At the same time they agreed that such type of collaborative work would have developed a critical mind in them. Moreover, they would also expect in future to have extra-curricular activities to form an integral part of academic programmes where they would be required to actively collaborate.

**Motivation to pursue further studies**

From the questionnaires, 95% of the students stated that they underwent a smooth transition from secondary to tertiary level. However, during the interview, they highlighted that the first year was truly challenging and shocking as they were not prepared to face such a drastic change from secondary to tertiary level. The interview also revealed that the transition was not really that smooth. They inferred that there is world of difference between secondary and tertiary but if they had developed a critical mind in secondary, the transition would have been easier. They were expected to display a number of skills, such as creative, independent or innovative to be able to construct knowledge. Being scarce of those skills was a severe handicap to learn higher order concepts at tertiary.

During the interview, the students expressed that they were motivated to enter tertiary education, but their motivation gradually faded over the semesters as they could not display the required level of creativity and innovation. Hewitt (2000, cited in Edwards and Quinter, 2011) considers intrinsic and extrinsic factors as determinant for career choice. The students’ decline in motivation results from the fact that the extrinsic factor was not present.

The questionnaire and interview reveal that they were motivated to pursue further studies given that they could not get jobs after graduation. In such case, the students preferred to embark on a higher level degree programme, with the expectation that they would then get a job after completing it.

**5 LIMITATIONS**

This study has several limitations. First, the study was limited to only three institutions with a small sample of students, thus the findings cannot be generalised to the national level.
Another limitation is that individual interview could have provided in-depth information but due to time constraints this could not be done.

6 CONCLUSION
This study has revealed a number of salient issues related to the gap existing between the secondary and tertiary levels of education in Mauritius concerning creativity and innovation in Science and Technology. In the era of globalisation, the present education system does not respond to the upcoming threats that Small Island States would experience. SIDs are very vulnerable to socio-economic challenges and our survival is dependent on how creative and innovative we are. Because of the complex and dynamic nature of the job market, a paradigm shift in the educational system will bring a breath of fresh air to our human capital. The only resources that we have are the human resources and filling the loopholes will certainly bring a new dimension to how secondary and tertiary education should evolve. All the stakeholders involved (parents, teachers, students, governmental and non-governmental agencies) should be prepared to take up this challenge for the benefit of our future generations.

REFERENCES


**Reports/Newspaper**


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