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Engineering research output in open distance learning - a South African comparative study

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ABSTRACT: Engineers play an important role not only in conceptualising, designing and manufacturing new products, processes and systems, but also in the maintenance and improvement of the same to ensure that everyday operations run smoothly. In this respect, research in engineering is expected to remain vibrant, whilst being relevant to address the myriad real life challenges in industry. There is a general concern that research from faculties of engineering markedly lags behind other faculties. Furthermore, there is a notion that academics from faculties of engineering in distance education universities produce even fewer research outputs compared to those at conventional face-to-face institutions. This article seeks to investigate the research activities of the School of Engineering at the University of South Africa (UNISA), comparing this with other schools in the College of Science Engineering and Technology (CSET). Comparisons of research output in the College of Science, Engineering and Technology and other colleges at UNISA were conducted. This comparison includes also other universities in South Africa. This study shows that the outputs from the School of Engineering are comparable to those of other schools in CSET. However, CSET's research outputs are low compared to other colleges.

Keywords: Research output, engineering research, open distance learning

INTRODUCTION

Engineering plays an important role not only in conceptualising, designing and manufacturing new products, processes and systems, but also in the maintenance and improvement of the same to ensure that everyday operations run smoothly. In this respect, research in engineering must remain vibrant, whilst being relevant to addressing the myriad real life challenges in industry. Universities, being centres of excellence in teaching and learning are seen as centres tasked with driving the research function. There is a general concern that research from faculties of engineering at different universities markedly lags behind research produced by other faculties. Furthermore, there is a notion that production of research outputs is even less at faculties of engineering in distance education universities compared to those at conventional face-to-face institutions.

This research was carried out in order to establish if the generally accepted notion that research from the faculty of engineering is less than from other faculties in open and distance learning (ODL) institutions is true or false. The publishing productivity of faculties is very important, giving the institution prestige and stature compared to other institutions [1]. The research activity of individual faculty members is significant as it contributes towards the research outputs of institutions. This study focuses on research outputs data from the three schools in the College of Science Engineering and Technology (CSET) at the University of South Africa (UNISA). The data were collected from university reports based on records of previous and current research activities of university staff members in the schools of engineering, computing and science. In addition, research activity data were collected from the departments through quarterly tuition reports. The information is collated by each school and, then, utilised to produce the annual research reports for each college.

Whilst considering the kind of research outputs to be used for the basis of comparison, the authors settled on using data from the CSET, because the schools conduct similar *scientific* kinds of research that is based on laboratory experiments, industry-based research and field testing data. Typically, the research makes use of fundamental science and engineering principles and mathematical analysis to draw conclusions. In this respect, the results are more analogous when compared with results from education, social sciences and management science research that may often take a very different approach.

UNISA is a leading university in South Africa offering qualifications through ODL mode. ODL is a model of teaching and learning in which the lecturers and learners are separated from each other in terms of distance and time, among other

things. UNISA does not offer face-to-face tuition. Learners learn from their homes through teaching material that is either posted or can be accessed on-line from the UNISA Web site. The word *open* refers to open access. ODL institutions should ideally proffer greater access of entry to learners compared to face-to-face institutions, where places are restricted because of limitations of resources. Limitations are imposed by the siting capacity of results, because of the limitations of numbers that can be enrolled at any given time and, therefore, there are stringent requirements to get a place. Because, learners do not have to be physically on campus for learning to be effected in the ODL model, there is greater access for the learners at an ODL institution compared to a traditional institution offering tuition through the face-to-face model.

The impact of country boundaries and time zone implications are also not a limitation in ODL institutions. This, however, might mean lecturers are required to do more work in compensating for the reduced contact with learners. This makes it imperative to use other tools, including ICT and multimedia resources. The increase in the activities lecturers are required to perform to achieve effective teaching and learning implies that lecturers at ODL institutions might have less time for research leading to fewer research outputs compared to lecturers at conventional universities. This effect is perceived to have a greater impact on such fields as engineering, which are perceived to be very challenging to learners. The extent to which this can be taken to be true is the focus of this current work. The findings from a number of research papers seem to concur that there are fewer research outputs from faculties of engineering than from other faculties. This was the conclusion from an investigation conducted at an ODL institution in Sri Lanka [2]. This research is important not only in the comparison of research outputs from engineering faculties against outputs from other faculties, but also in the fact that the institution considered offers engineering in ODL, just like UNISA.

Similarly, findings from research conducted at Southern Nigerian universities [3] and the Islamic Azad University of Zahedan Brach showed that faculties of engineering fare less favourably to the other faculties when comparing research outputs in terms of relative efficiency of teaching and research [4]. Whilst a researcher may be rated in terms of the number of outputs produced, recently there has been a shift towards the impact of the research that one is conducting. The impact is mainly measured by the citations of a researcher's work and the impact factor of the journal that a researcher publishes in [5]. The rating of researchers by measurement of the citations on their publications is referred to as bibliometrics. Rating of research may also be based an analysis of authorship patterns, collaboration, designation and experience distributions in what is called scientometric studies [1].

Rating of research is important in more ways than just for the comparison of faculties and universities. In some universities, it has become a performance appraisal tool through which staff members deemed to be performing below the expected level are required to come up with an improvement plan [6].

In recent years, it has been reported that there has been a marked increase in research outputs from science and engineering. It was noted that the output from Africa in those fields has doubled over the last decade. While a general increase in both science and engineering outputs have been reported (Reksulak Michael) [7], it has been mentioned that there is a greater increase in outputs from engineering compared to science outputs [8]. The article noted a substantial world-wide increase in engineering research outputs compared to outputs from science. The increase was especially notable in Asia with China, taking about half of the share of the growth reported.

METHODOLOGY

Research outputs data from the three schools in CSET were collected and analysed to establish how the School of Engineering (SOE) performed compared to the other schools in the College. A bibliometric analysis of the research outputs from the schools was also conducted to investigate the impact of the research from the three schools in terms of citations from the research outputs. According to Google Scholar, citations were collected for each output and the results analysed. A comparison of the outputs from the colleges at UNISA was then conducted, followed by a comparison of UNISA and other universities in South Africa.

ANALYSIS OF RESEARCH

Data on research activities in different departments at UNISA is compiled per quarter in Quarterly Tuition Reports, which are then collated in the schools and further collated in the colleges to produce college reports. The annual research reports for CSET for the years 2011 to 2013 were used to compile the data on the research outputs in this article. Table 1 shows all research outputs for the three years under focus for both refereed and non-refereed journals, including papers accepted for publication, all conference proceedings and presentations. It should be noted that conference presentations and accepted papers only get research points after publication.

Table 1 indicates that the schools in CSET have different strengths in terms of the type of outputs. The School of Science (SOS) has more outputs in journal publications, which generates more research points per output compared to conference proceedings and book publications, whilst the School of Computing (SOC) produces more outputs in conference presentations. SOE seems to average the outputs of the other two schools in terms of both journal publications and conferences. The trajectories of the corresponding total outputs of journal publications, conference presentation and book contributions for the schools for the three years are shown in the graph in Figure 1.

Table 1: The number of research outputs per school for the years 2011 to 2013.

School	Year	Journal	Conference	Books
Computers	2011	15	44	2
	2012	11	26	7
	2013	24	64	3
Engineering	2011	21	25	-
	2012	21	40	8
	2013	24	20	3
Science	2011	42	2	-
	2012	41	-	2
	2013	37	-	1

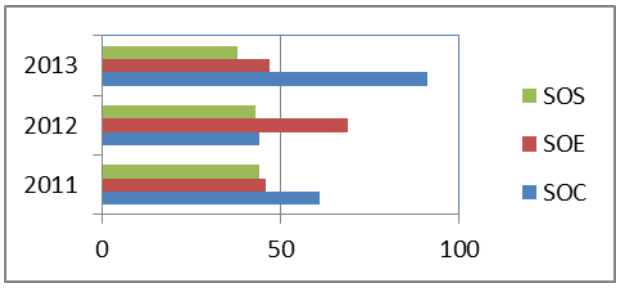

Figure 1: The trajectories of the total research outputs per school for the years 2011 to 2013.

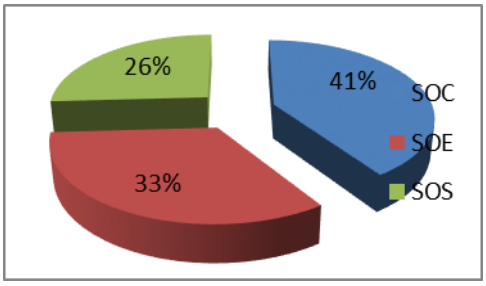

Figure 2: Average output per school for the years 2011 to 2013.

The graph reveals that outputs from the School of Engineering are comparable to the outputs from the other schools. The results actually show that the School of Engineering had the highest total outputs for 2012. The average outputs for the same period is shown in Figure 2.

Research points earned per school for each year are an important statistic in analysing research outputs. Research output points can be viewed as the quality of research from each output. In this respect, a publication in a refereed journal earns one point, a publication in a conference proceeding journal earns half a point (0.5), whilst there are no points for publications in non-refereed journals. A peer-reviewed book publication earns half a point (0.5). Refereed journals in South Africa are those appearing on the approved Department of Higher Education and Technology (DHET) list for each year. Table 2 below gives the research points earned per research per school per year.

Table 2: Research output points per school for the years 2011 to 2013.

School	Year	Journal	Conference	Books	Total
Computing	2011	7.72	10.79	0.77	19.28
	2012	5.37	8.058	2.917	16.345
	2013	13.56	25.672	0.25	39.482
Engineering	2011	10.47	10	-	20.47
	2012	9.29	15.529	3.5	28.319
	2013	4.87	6.695	2	13.565
Science	2011	27.29	0.34	-	27.63
	2012	24.17	-	1	25.17
	2013	22.85	-	0.5	23.35

The research output points represent the funding earned by the university from DHET for research outputs. A portion of the money earned by the university finds its way to the college, school, department and the individual researcher(s). It is preferred to have publication in refereed international journals not only for the purpose of earning points and funding from DHET, but also for greater visibility on the world stage with possible opportunities for collaboration and greater chances of citation by other researchers at that level. It should be noted that research points are only awarded to UNISA members of staff. In cases of collaboration, researchers from other institutions are not awarded any points at UNISA. The total number of points that accredited to UNISA depends on the output type (journal, conference or book) and the number of UNISA researchers involved in each research output, and this then represents the allocation of funds from DHET to UNISA.

One other interesting characteristic to look at is the impact of the research from the three schools, as discussed above. Bibliometric analysis has gained application in different forums as a way of measuring research outputs, besides the number of actual outputs. In an investigation of the research outputs, compared to other institutions the authors were tasked with gathering data on the research outputs, the citations and impact of publications [9]). For the purpose of this study, only citations have been considered. The graph below was drawn out of the Google Scholar citations of the research outputs as at 19 March 2015.

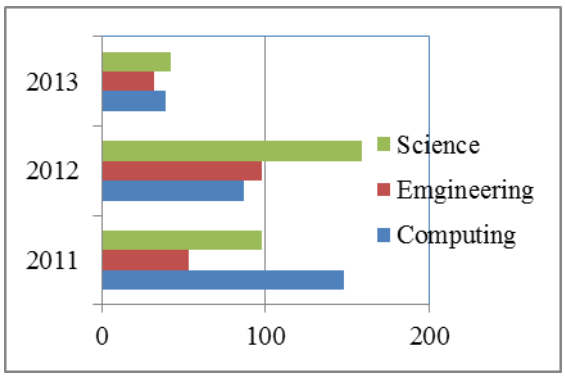

Figure 3: Number of Google Scholar citations for the outputs from the years 2011 to 2013.

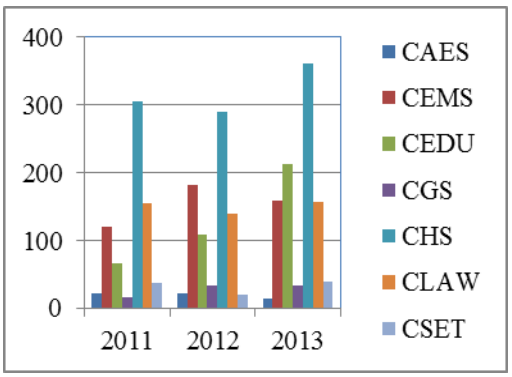

Figure 4: Research output points from the colleges at UNISA for the years 2011 to 2013.

Points to note from citation results are as follows:

- The School of Engineering starts much lower than the other schools in 2011 and increases to a level that is comparable with the other schools in 2012.
- Thereafter, the results from the schools for 2013 are all low, but again similar. The rather low results for 2013 outputs could be attributed to the shorter time since the time of publication of the papers to the time of consideration in this article. This would mean that a similar exercise at this time next year will yield results that are quite different.
- What is important from this analysis though is the fact that citations from the School of Engineering on the outputs for the years 2012 and 2013 are very comparable to the citations from the outputs from the other schools.
- This shows that the research from the School of Engineering is generating interest from other researchers to the same level as the outputs from the other schools.

Whilst the contribution of the School of Engineering within the College of Engineering, Science and Technology CSET has been analysed, the actual contribution of the School of Engineering in the University as a whole can be seen from a comparison of the different colleges to the total UNISA research output. Furthermore, a comparison of UNISA against other universities in South Africa can give an indication of how the School of Engineering fares when compared to departments from other universities.

So far, only the outputs from CSET have been analysed. A focus on the annual research outputs from all the academic colleges at UNISA will now follow. This gives information on how research outputs from CSET as a college compares with outputs from other colleges at UNISA. Table 3 shows the research output points earned by the academic colleges at UNISA; namely, the Colleges of Agriculture and Environmental Sciences (CAES), the College of Economic and Management Sciences (CEMS), the College of Education (CEDU), the College of Graduate Studies (CGS), the College of Human Sciences (HS), the College of Law (CLAW), and the College of Science, Engineering and Technology (CSET). Figure 4 shows the research output points from the colleges for the years 2011 to 2013.

A close look at the graph shows the CSET averages out in the fifth position out of the seven colleges at UNISA. The main contributors are CEMS, CEDU, CEMS and CLAW, whilst outputs from CSET, CAES and CGS are very low in comparison. The number of college staff members contributing to research outputs for the years 2009 to 2013 is shown in Figure 5. This again refers to lecturing staff and other staff specifically focusing on research, including postgraduate fellows.

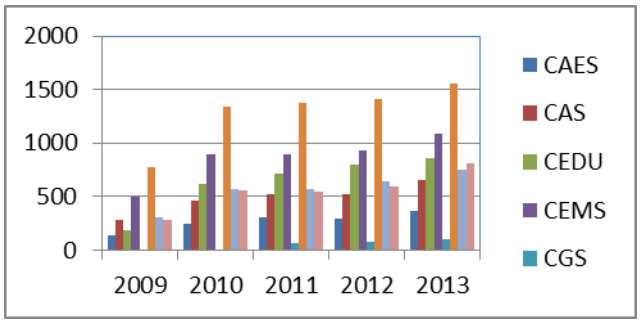

Figure 5: Instructional/research professionals HC by college, 2009-2013.

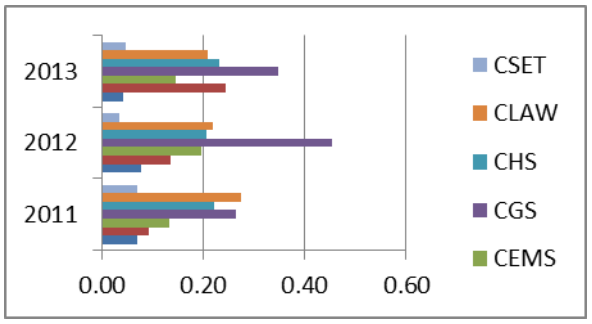

Figure 6: Average research outputs per individual for the years 2011 to 2013.

From the graph of the staff complement for the colleges, it can be seen that the four colleges CHS, CEMS, CEDU and CLAW had more staff members compared to CSET for the years under review. Topping the list in staff complement was CHS, which has more than double the number of staff of CSET except in 2013, when CSET experienced a 17% increase in the number of staff, which is quite a big jump. With the larger numbers of staff compared to CSET, it should be

expected that the four colleges with larger numbers should have greater outputs. To get a clearer picture of the comparative college performance, an analysis of the average research outputs per individual was done for the years 2011 to 2013. The results are shown in Figure 6.

The highlight of this graph is that CGS, which records the lowest research output points tops the list in the output points per individual as a result of the much lower number of members of staff. Another interesting result is that CSET seems to be performing less than the other colleges for the three years under review. This finding seems to be in agreement with findings elsewhere where the outputs from science and engineering when compared to other disciplines. Another key point in other research conducted in this respect also noted a marked increase in the outputs from engineering and science compared to outputs from other fields.

It is interesting to see how research outputs from UNISA compare with that from other institutions of higher learning. Such information is compiled annually by the government's DHET. At UNISA, it is accessed through the Directorate of Information and Analysis (DISA). A comparative graph of the research outputs from the universities in South Africa in 2012 is shown in Figure 7.

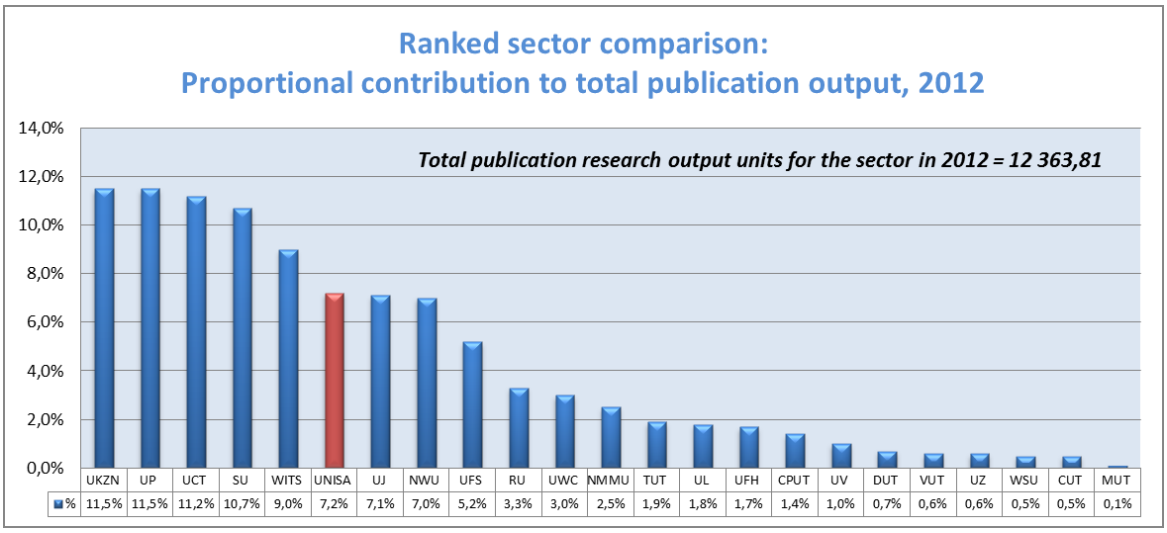

Figure 7: Research outputs from South African universities for 2012.

Figure 7 shows the comparison of UNISA against other universities in South Africa. The position of UNISA against other universities in similar comparative analysis of the outputs from South African universities is summarised in the table below, which is extracted from a report prepared by the Research Department for research performance of UNISA, 2015).

Table 3: The ranked position of annual research outputs from UNISA against other universities.

	2008	2009	2010	2011	2012	2013
Publication output	6th	6th	6th	6th	6th	7th
Research Master's graduates	12th	14th	14th	11th	7th	8th
Doctoral graduates (weighted)	8th	8th	9th	8th	6th	6th
Total weighted research output	7th	8th	9th	7th	7th	7th
Weighted output per capita	7th	8th	9th	7th	7th	7th

For the years under focus, the universities that are consistently producing more research outputs compared to UNISA are the University of KwaZulu Natal (UKZN), the University of Pretoria (UP), the University of Cape Town (UCT), Stellenbosch University (SU) and Wits University (WITS). These are the top established universities in South Africa. UNISA is the only university that offers tuition through the open distance education (ODL) mode.

DISCUSSION AND RECOMMENDATIONS

A comparison of research outputs from the three schools in CSET shown in Figure 1 seems to indicate that the School of Engineering is performing just as well as the other schools. Actually for 2012, the outputs from engineering were the highest for the College. Similarly, the average annual outputs pie chart in Figure 2 for the three years shows that the average outputs from the School of Engineering lies in between the average outputs of the other two schools. This result is contrary to the commonly accepted position that the outputs from engineering are significantly lower than that from other faculties. Considering the College of Science Engineering and Technology only, this result contradicts the expected result that the School of Engineering has much lower outputs. Rather it shows that the School of Engineering is performing, as well as the other schools in the College.

Table 2 shows that the research output points follow the same pattern as the number of publications. This means the earnings for research for the three schools is comparable for the years in focus. As with the other factors that have been looked at, evidence shows that citation of publications from the School of Engineering for the years 2011 to 2013 is more or less comparable to citations for publications from the other two schools. This suggests that the quality and impact of the research outputs from the School of Engineering is at the same level as that from the other two schools. Whilst citations have been used to rate the impact of research outputs, there are some arguments against the usefulness of citations as a tool for measuring the impact of research output. Below are some issues to consider.

Research in an area where there are more players is going to have more citations compared to research in an area in which there are fewer players. In some cases, some research may be working in an area where there is a large work-group in which there is a lot of referencing of own and colleagues work, such that the actual impact is localised, being confined to members of the work-group. Lack of citation may occur when someone is in a ground-breaking area in which there are no other players at the time of the research, even though the ground-breaking work will then lead to a lot of research activity in later years. At the time of the research, however, there is likely to be less activity around the work from other players. In this case, at the time of the research people are not fully conversant with that line of work and so they are not engaging in that kind of work. Again, work that may not generate much interest in terms of citation may on the other hand create a lot of activity in terms of practical implementation, which may not be reported in research papers. That being said, the citations on an article still remains an important indication of the impact of a research publication, though there may be other means of determining its impact.

Besides citations, there has been an argument that the journal that a researcher publishes in is another indicator of the importance of one's research. The counter-argument, however, contends that an output is an output irrespective of the journal and should be treated with as much respect [10]. For the purpose of this article, the impact of the outputs is only considered in respect of the citations. College research outputs graph in Figure 4 shows that CSET as a college is on the low side as compared to the highest performing colleges, which are CHS, CLAW, CEMS and CEDU. CSET seems to be doing better than CAES and CGS in the results shown. It can be said that whilst the School of Engineering performs comparatively well with other schools in CSET, the College itself has lower outputs compared to other colleges within the University. It can be seen from the result of the *per capita* output points graph (Figure 4) that CSET is performing at a lower level than the other colleges, confirming the earlier findings from of the college research output points.

A comparison of outputs from the different universities in Figure 7 indicates that UNISA is above average, based on 2012 outputs. Whilst the four top best-performing universities contributed about 11% each, UNISA and two other universities contributed about 7% of outputs each. At the lower end, about five universities contributed less than 1% of total output, while one contributed ~0%. This shows that while UNISA is offering tuition through the ODL mode, it still fares well in terms of research activity. From this it can be inferred that the School of Engineering from UNISA also fares comparatively well with respect to outputs against faculties from conventional universities in South Africa. From these results, it can be seen that research from engineering activity is initially below that from other schools at UNISA. This could be as the result of a number of reasons:

1. The School of Engineering was part of Technikon SA, a technical college and only became part of UNISA when Technikon SA merged with the old UNISA in 2005 to form the new UNISA. The lecturers in Technikon SA were not research-oriented, but were as hands-on oriented as those at UNISA. Winberg et al highlights the difference in research and hands-on orientation in the traditional universities and Technikons in South Africa [5] and the transformations as academic staff in the universities of technology acquire higher qualifications and research orientation in the post-independence era. The gap in the research productivity of the two types of institutions should gradually disappear as the former Technikon staff gradually embrace the research ethos of the former traditional university, especially, when the two are brought together through mergers. This becomes possible as the Technikon academics acquire higher degrees and become embraced in the research environment that is fostered by the presence of the staff from the traditional university.
2. Most lecturers had up to BTech as their highest qualification at the time of merger in the School of Engineering. As a result of the merger, lecturers became busy with upgrading qualifications, whilst in the other schools the focus is research.
3. The highest qualification offered for most disciplines in engineering is BTech. At this level, there is minimum focus on research for the learners. In the other schools the focus is research, with Master's and PhD qualifications being offered. Learners contribute immensely in the research outputs from the schools.

The future of research looks bright, as attested by the gradual increase in the research outputs from the School from the years 2011 to 2013. This should be a result of the following:

1. Trend analysis reveals that there is an increase in members of staff with higher degrees in the School of Engineering through further studies and recruitment.
2. Masters and PhD qualifications are being introduced in almost all disciplines.
3. New laboratories have been built for undergraduate and postgraduate studies, and for lecturers' own research.

The following are the recommendations to the School of Engineering and its departments:

1. The school is recommended to hire accomplished professors who are able to mentor junior academics and foster a culture of research. UNISA has a well-supported mentorship programme that the departments can take advantage of in raising the level of research.
2. Departments need to create environments in which staff members can study for higher qualifications with much reduced workloads. At UNISA there are several programmes to assist academics to further their qualifications.
3. Capacity building with research laboratories that are well equipped. The school has recently received new laboratories. It is important to ensure that academics actively participate in procurement of research equipment to oil the research activities.
4. Create collaboration platforms with other institutions. UNISA actively participates in the BRICS initiative and departments must forge local collaboration arrangements to assist academics' research efforts.
5. Incentivise research effort of departments and individuals. UNISA has brought in research incentives, including monetary going to both departments and individuals, which also impacts on pay progression and grading. Departments must ensure academics are well aware of these.
6. Build publication platforms - engineering conferences in collaboration with other local and international institutions of higher learning where faculty members are encouraged to publish their work. There should be active research groups in the departments/school with regular meeting that encourage activities from members.

CONCLUSIONS

Whilst it is generally accepted that faculties of engineering at ODL institutions produce fewer research outputs compared to other faculties, this investigation gives results that are not that conclusive. It has been shown that the School of Engineering has results that are comparable to other schools in the College of Science Engineering and Technology.

Outputs were found initially to be lower due a number of reasons that include the lack of research orientation, because of the technical college background, lower numbers of academic staff members, lack of postgraduate students and lack of staff members with higher qualifications. The changing position of the School of Engineering as all these issues are being addressed is seen to be bringing good research output results. It has also been shown that UNISA does not fare badly when compared to the face-to-face institutions.

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BIOGRAPHIES

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