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1 INTRODUCTION

As knowledge becomes a key factor in 'development', whether human, social or economic, the importance of higher education and research, especially within science and technology, as generator of knowledge is increasing throughout the world. This increasing importance of higher education and research poses challenges to universities everywhere in terms of changes in the mode of knowledge production, teaching and learning and in terms of political pressure for increasing number of students. In 'developing' countries in general and in the African countries specifically these challenges are added to a number of long-standing challenges to higher education due to social and economic problems specific to the continent (World Bank 2000; World Bank 2002; Bloom et. al. 2006). In this paper we will first describe the challenges facing universities in 'developing' countries in general and more specifically in Sub-Saharan Africa. Based on this description we will discuss whether the introduction of a problem based learning approach to teaching and learning might present a viable solution to a number of the challenges.

2 CHALLENGES FACING AFRICAN UNIVERSITIES

One major challenge facing most of the African universities is *lack of resources*. The history of African universities from independence up to now reveals a long period of time with a consistent neglect of higher education. Structural Adjustment Programmes (SAPs) during the 1980s and 1990s directed international donor funding away from higher education towards primary education, a trend which was mirrored in African governments' relative neglect of the sector as well (Bollag 2004; Sawyerr 2004). Concurrent with the reduction of financial resources from government and international donors, universities had to shoulder huge increases in enrolment of students. The total enrolment in African universities went from 181.000 in 1975 to 660.000 in 1985 to 1.975.000 in 1995 and the gross tertiary enrolment ratio, that is, the percentage of young people aged 19-24 who are in university, increased from 1.6% in 1980 to 3.6% in 1996, an increase which is not likely to stop within the near future (Sawyerr 2004). In spite of the impressive increase the gross tertiary enrolment ratio is considerably lower for Africa than for any other part of the world (World Bank 2000).

Thus, African universities have been faced with the double challenge of decreasing funds and increasing enrolment, a combination which has led to a prolonged crisis from which many of

the universities have only partly recovered (Sawyerr 2004). Reduced funding and increased enrolment inevitably has led to a decrease in educational quality, thus adding to forces of brain drain and the need for donor funded 'import' of educational programmes and staff from abroad. Many universities have started addressing this challenge through institutional reform programmes focusing upon financial sustainability and self-sufficiency but lack of resources remains a major challenge for most public African universities.

Another major challenge which African universities did indeed address, albeit with limited success during the first years of independence, is the *de-colonisation* of higher education, re-defining and re-adjusting the curricula to be(come) relevant in an African context. The curricula need to be responsive to problems in African society and to deliver solutions useful in the African context. Thus, there is a need to move from Eurocentric and US-centric perceptions of education and knowledge to specific African perceptions of these concepts and to specific African curricula, developed by and for Africans in Africa.

It may seem self-contradictory that the authors of this paper, two European women, are proposing educational change towards PBL for Africa while arguing that African curricula should be developed by Africans. The point is, however, that we are not proposing any specific European model of education, teaching and learning; rather, we are proposing that African universities consider a set of principles of teaching and learning which have proven their value in a European context and further consider trying out some of these principles which might also prove their worth in an African context. The development of an African educational model of PBL should be the responsibility of and carried out by African academics themselves. Furthermore, we are not proposing that African universities scrap all scientific and technological knowledge from the West and start re-inventing the wheel; rather, we are proposing that African academics critically re-examine and re-adjust existing knowledge developed in other parts of the world, with the aim of accommodating and applying it - in combination with locally generated knowledge - to the solution of specific African problems.

A challenge stemming from the above mentioned increasing importance of higher education in the global knowledge economy is a call for a changed mode of knowledge production where focus is on actively generating, adapting, applying and using knowledge for problem solving rather than on passively acquiring and storing knowledge:

> “The new patterns of knowledge creation imply not only a reconfiguration of departments into a different institutional map but more importantly the reorganization of research and training around **the search for solutions to complex problems**, rather than the analytical practices of traditional academic disciplines.” (World Bank 2002, p. 37; emphasis added)

In this endeavour for a change in modes of knowledge production African countries may run a risk of being left behind because the universities in these countries are not well positioned to tackle this challenge:

> "Developing and transition countries are at risk of being further marginalized in a highly competitive world economy because their tertiary education systems

> are not adequately prepared to capitalize on the creation and use of knowledge." (World Bank 2002, p. xix)

Thus, another challenge closely linked to changes in knowledge production is to introduce *changes in learning and teaching*. The challenge is to improve the learning and teaching processes to cater for an increasing demand for graduates who are able to generate, process, adapt and apply knowledge:

> "The learning process now needs to be increasingly based on **the capacity to find and access knowledge and to apply it in problem solving**. Learning to learn, learning to transform information into new knowledge, and learning to translate new knowledge into applications become more important than memorizing specific information." (World Bank 2002, p. 29; emphasis added)

As was mentioned above high and increasing enrolment is likely to continue for some time to come. A challenge for universities is to cope with *mass education*, i.e. high numbers of students, some of whom have poor entry qualifications and most of whom are male students from well-to-do families from certain ethnic groups of the countries (Mkude et. al. 2003). Thus, issues of *poor entry qualifications* and of increasing *inequities* in terms of gender, ethnicity and socio-economic background feature high on the list of challenges to be addresses by African universities (Sawyerr 2004).

A challenge which is linked to the incomplete de-colonisation process and thus the lack of relevance of curricula is the unresponsiveness of higher education to the needs of enterprises, communities and society in general. The lack of close links between the institutions of knowledge creation and the beneficiaries of this knowledge leads to *weak innovative capacity* at the national level. It also has as a consequence that students do not get many opportunities to gain experience working in a meaningful way with local experts on solving local problems. Thus, a risk of alienation towards the local African society exists. A part of the challenge of weak links has to do with the employment situation of graduates. The downsizing of employment opportunities which has taken place in most Sub-Saharan African countries in the wake of the above mentioned SAP programmes, leading to dismantling or privatisation of governmental and parastatal corporations and companies, means that where graduates earlier were guaranteed a job after graduation, they now have to look for jobs themselves in a small formal private sector which is often not satisfied with the competences of the graduates or else they have to become entrepreneurs and create their own jobs. This has led to fairly high *unemployment* rates among university graduates (Mkude et. al. 2003).

The last but not the least challenge to be discussed is the *brain drain* from Africa to the US and Europe. This is certainly not a new challenge - the exodus of highly qualified Africans, educated in their home countries and emigrating to the West, started already during the first decade after independence but increased dramatically during the late 1970s and the 1980s. Thus, an estimated average per year of 1.800 highly skilled migrants left Africa during 1960-75, a figure that rose to 23.000 from 1984-87 (Ndulu 2004). To give an indication of the extent of the problem Ndulu writes:

> "More African scientists and engineers are working in the United States than there are in Africa. The emigration of technically skilled people has left only

> 20,000 scientists and engineers in Africa to provide services to 600 million people." (IOM 2000; here quoted from Ndulu 2004, p. 60)

This brain drain is connected to the above mentioned unemployment rates as well as to the generally poor prospects of finding jobs providing satisfactory living conditions in poor African countries as compared to the rich Western countries. It is, however, also connected to a discourse of not regarding knowledge constructed in an African institution as valid – one must go to the West to obtain "real" knowledge. Students going abroad for further studies contribute to the brain drain; thus, estimates indicate that approximately one-third of foreign students studying in the US never return to their home countries (World Bank 2000). The brain drain costs Africa large sums of money in terms of educational investment. In 1990 alone it is estimated that educational investment in highly skilled emigrants to the US was US$ 640 mill. (Ndulu 2004).

Another aspect of this problem which could be labelled 'virtual brain drain' is the fact that African researchers often choose research topics and methods that mimic Western research, rather than working with local problems, in order to be(come) part of mainstream research (World Bank 2000).

The challenges discussed above are but a part of the challenges facing African universities. They are, however, challenges which we postulate might be successfully addresses by introducing a problem based approach to learning and teaching. In the next section we will turn to a discussion of the possible impact on the above challenges of introducing problem based learning into the curricula.

3 OVERCOMING THE CHALLENGES THROUGH PROBLEM BASED LEARNING?

In this section of the paper we will draw links between the above described challenges facing African universities and societies and the documented and/or predicted advantages of introducing problem based learning, in an attempt to point to possible solutions to some of the challenges. But first a short explanatory note on problem based learning (PBL).

Problem based learning: Problem based learning represents a radical shift in educational thinking from a teacher-centered approach to teaching to a student-centered approach to learning, i.e. the focus is shifted from the teacher actively teaching to the students actively learning. This student-centered learning approach is supported by the learning theory known as 'constructivist learning' which emphasizes that 'learning' is an individual process of constructing knowledge and meaning, based on active transformation of experiences and processing of information. Thus, learning is an individual process which can, however, be greatly enhanced by collaborative activities.

Based on the constructivist learning theory the core principles of PBL (Graaff and Kolmos 2003) are: problem orientation; project organisation; team work; interdisciplinarity; experiential learning; action-oriented learning; participant directed learning; democratic dialogue; linkages between theory and practice; critical enquiry, analysis and thinking;

exemplarity. Studying in a PBL environment develops the students' analytical, methodological and social competences, such as: ability for critical thinking and analysis; problem solving skills; project management skills; communication, negotiation and conflict resolution skills; life long learning skills. All of these are competences which are in demand in industry in a modern knowledge society.

Lack of resources: One of the most obvious advantages of introducing PBL seen from an institutional perspective is more efficient education and therefore better utilization of meager resources. Working with real life problems of importance to people outside the university enhances students' motivation for studying. Students who are more motivated experience decreased drop-out rates and shorter completion times; thus, less money is wasted on unsuccessful students who either drop out or never complete their studies. In a statistical survey performed by Universities Denmark it was found that in the year 2005 the % completion rate, i.e. completing in scheduled time plus 1 year, for engineering students at Aalborg University (AAU) with a PBL curriculum was 70% against 45% in the Technical University of Denmark (DtU) which has a more traditional lecture based curriculum. Drop-out rates in 2005 at the two institutions were 21% and 33%, respectively (Universities Denmark 2008). Although the differences may not be attributed solely to the different approaches to learning and teaching, since the two institutions differ also in other respects, the figures are still thought-provoking.

Drawing upon the students to teach each other in a peer teaching/learning scheme may reduce the workload on staff dealing with large numbers of students. Also, the time spent on lecturing and marking of exam papers may be reduced considerably (Arthur 2008), leading to more efficient use of staff resources. Another advantage is that institutional introduction of PBL necessitates improved interdisciplinary staff collaboration around education - and thus enhances the potential for interdisciplinary problem based research carried out in collaboration with society in general and local industry specifically. The real life characteristic of the PBL approach means that the problems forming the point of departure for the learning process may be solicited from industry, even in the early years of study, thus enhancing the collaboration between university and industry. Also, the graduates acquire relevant and useful competences, leading to a better match between the competence profile of graduates and the needs of industry. The point here is that closer collaboration with industry may induce in industry a greater interest in education and may eventually lead to income generating activities for the university.

De-colonisation: Introducing a PBL approach may to a great extent assist in the move from Westernised to Africanised knowledge, due to the emphasis on identifying and applying local, formal and informal knowledge in the analysis and solution of a local real-life problem, rooted in a social context rather than within a textbook. To illustrate the contextualisation of problem based projects a project example from Aalborg University, 1st Year Electronics engineering is given:

> "Pasteurisation is a heating process whereby water may be cleaned of bacteria etc. to become suitable as drinking water. In Tanzania this heating is most often done using firewood which is in short supply. Using solar energy of which there is plenty it is possible to reach temperatures high enough for pasteurisation of a

> given fluid, depending upon how the fluid is kept. But a problem with solar energy is that it cannot be controlled.
>
> Thus, there is a need for a simple and cheap device which can monitor temperature and time and in a simple way inform the Tanzanian user (who may be illiterate) when the pasteurisation is successfully completed." (EE 2007)

The project example is obviously not drawn from a local Danish context; however, it is a contextualised, real-life problem and not a textbook problem. The students working on this problem had access to contextualised expert knowledge on social, economic and political conditions in Tanzania while also having access to a substantial pool of scientific knowledge on utilisation of solar energy. Combining the two types of knowledge allowed the students to design a solution which could be implemented in Tanzania.

Students in a PBL curriculum draw upon local contextualised indigenous knowledge as a source of input to their learning processes, thereby enhancing the status of this knowledge, while at the same time integrating it with the de-contextualised knowledge created in the West which they have to adapt to the local context and to the local needs.

Moving away from the traditional Eurocentric modes of education will mean moving away from a constant measuring of self and of society against standards of the West, i.e. standards which are problematic in a global perspective. Instead, the quality of a project should be measured against its theoretical and practical contributions to the solving of problems rooted in the context of the country and the continent.

Changing perceptions of knowledge, learning and teaching: The creation of knowledge for complex problem solving is one of the hall marks of problem based learning, as are the characteristics of learning called for in the above quote from the World Bank report (2002, p. 29), namely: 'learning to learn, learning to transform information into new knowledge, and learning to translate new knowledge into applications' dealing with problem solving. Furthermore, because PBL integrates formal and informal learning from a diversity of different sources of information and learning, introducing PBL in African universities may assist in emphasising and promoting the specific and valuable African “niche” of knowledge in the global knowledge economy where knowledge more and more is becoming a commodity.

A PBL approach to teaching allows for closer linkages between teaching and research, i.e. students may work with problems which are derived from faculty members' own problem based research, thus allowing students to become familiar with research even from an early stage of their study. This means that introducing PBL in the first years of university education will boost the research capacity of students from an early stage and not only during their final thesis work, as is the situation at present. This might turn out good researchers who in turn may become new staff in the universities (Arthur 2008).

A last advantage to be mentioned here is that PBL emphasises a democratic approach to teaching and learning. This is particularly evident in the student-teacher relationship where critical thinking is encouraged and students are expected to formulate and raise critical questions rather than to answer questions in order to be able to solve the problem they are

working with. According to the constructivist learning theory, knowledge is not something to be transferred from teacher to student with no questioning, but rather something to be negotiated in class, with teachers and not least within students' teams when addressing their project work. Thus, a PBL approach enhances democratic ways of negotiating and interacting within students' teams and within society (Du et. al. 2007; Qvist 2008).

Mass education, poor entry qualifications and inequities: In dealing with mass education one important approach to teaching and learning is so-called peer learning, a greatly underutilized and highly effective method of learning. In a peer teaching and learning situation students teach other students, thereby "transforming a class of 500 students into 500 teaching assistants" (Biggs, 2003, p. 112). In connection with the team work in PBL students will teach each other, i.e. a great amount of peer teaching accompanied by peer learning takes place, and according to research on learning this is one of the most effective ways of learning. Peer teaching and learning enhances the quality of learning, while at the same time developing in the students a sense of responsibility for his/her own learning, as well as for the learning and personal growth of team members.

Concerning poor entry qualifications a PBL approach can considerably improve the performance of so-called ‘poor’ students, even more so than of so-called ‘good’ students, partly because of the peer learning, partly because other competences than the traditional 'academic' ones are needed to achieve success in a PBL environment. This point is illustrated in figure 1 which shows that shifting the focus from teaching to learning, i.e. shifting to student-activating forms of teaching, 'forces' non-academic students to engage with the material to be mastered in an active manner and as a result they learn better, thereby acquiring better competences and increasing their chances of completing the study.

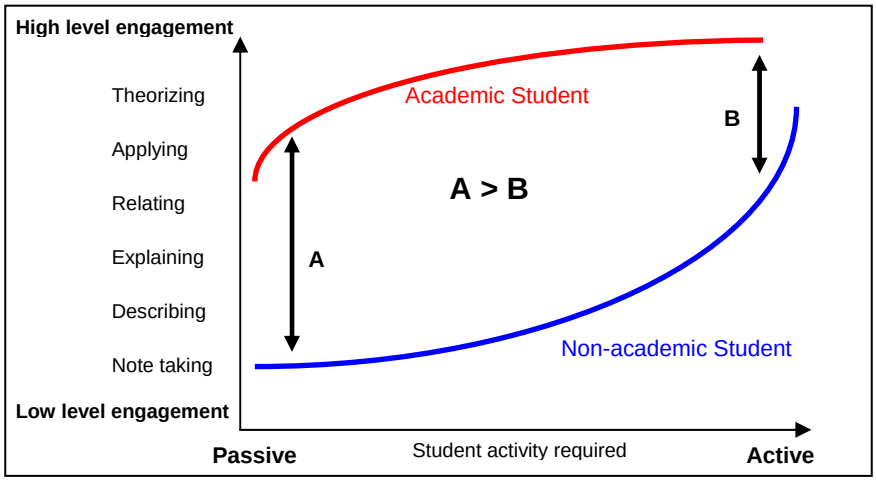

Figure 1: Student engagement as a function of activity required (Biggs 2003, p. 4).

The same effect was demonstrated in a study performed at City University of Hong Kong. First year students within the same field of engineering were divided into two groups: One group (group A) consisting of students with high entry qualifications for university (the 'academic' students) and another group (group B) with low entry qualifications (the 'non-academic' students). The two groups were to learn the same subject matter material, but through different methods of delivery: Group A was exposed to a traditional method of

delivery, i.e. lecture-based teaching, while group B was taught according to a completely problem-based learning approach. After 15 months of study the ‘non-academic’ students in group B showed considerable improvements (on average 27%) in meta-cognitive competences of planning, monitoring and evaluating their own learning, while there was hardly any change in these competences for the matched group A of ‘academic’ students (Downing 2007).

On the issue of ethnic and socio-economic inequities in recruitment and access to higher education a PBL curriculum may not be able to make much of an impact here, other than in terms of the improved performance of 'poor' students, as mentioned above. Concerning gender, however, the fact that in PBL students deal with real-life problems may attract more women to especially engineering studies, since research clearly documents that for women to be attracted to these hard-core technical studies they need to be able to visualise the application of technical systems and devices to solve real-life problems for real-life people (Du 2006).

Weak innovative capacity and unemployment: A stream of the discourse on development in the global knowledge economy is centred on the importance of innovation and of the existence of so-called ‘national systems of innovation’ for development (Masinda 1998). A study made for the Danish Agency for Science, Technology and Innovation showed that the innovative capacity of small and medium sized companies is greatly enhanced if the company staff is diverse in terms of education, gender and ethnicity (FIST 2007). Thus, increasing diversity by overcoming the challenge of ethnic, socio-economic and gender inequities in access to higher education would be likely to increase the innovativeness of universities and thereby enhance their contribution to national 'development' through national systems of innovation. Furthermore, as is documented in figure 2 below, PBL enhances innovative skills of graduates, partly because students are allowed to think and research for themselves and constantly have to be inventive and creative in drawing upon the application of theory to design of practical solutions, partly because PBL enhances diversity in knowledge generation through interdisciplinarity and thus releases the innovative potential of a diverse student body.

A 'national system of innovation' is of course strongly dependent upon good institutions of higher education and research, especially in science and engineering (Masinda 1998). Therefore it is crucial that the knowledge generated in universities also reaches out and is applied in enterprises and companies, both in the formal and in the informal sector. One way of securing this knowledge transfer from universities to industry and society is by securing that the graduates can indeed find a job after graduation.

From a Danish context it has been documented that PBL graduates have the competences required by industry to a higher degree than graduates from a more traditional study environment. In other words: A PBL approach to higher education responds more appropriately to the needs of the labour market. This was documented in a study examining employer satisfaction with university graduates (Kandidat 2002). Out of the respondents 57% of private employers preferred graduates from Aalborg University (AAU) to graduates from a more traditional university within the same region of Denmark. The reasons stated by the employers for this preference were that the AAU candidates possess: Project management skills; methodological and structured way of working; good skills in team work; innovation skills; ability to acquire new knowledge and skills. One respondent in the survey said:

> "The ones [i.e. the graduates] coming from, for example, Aalborg University, go in and work in projects from the start." (Kandidat 2002, p. 33)

Another survey on employer's satisfaction with competences of graduates was performed for the Danish weekly "The Engineer" (Danish: Ingeniøren) by Institute for Opinion Analysis (Ingeniøren 2004). In the survey human resources persons in 125 of the largest engineering companies in Denmark were asked to rate the competences of the new graduates from the more traditional engineering education at Technical University of Denmark (DtU) and from Aalborg University (AAU) with its PBL approach.

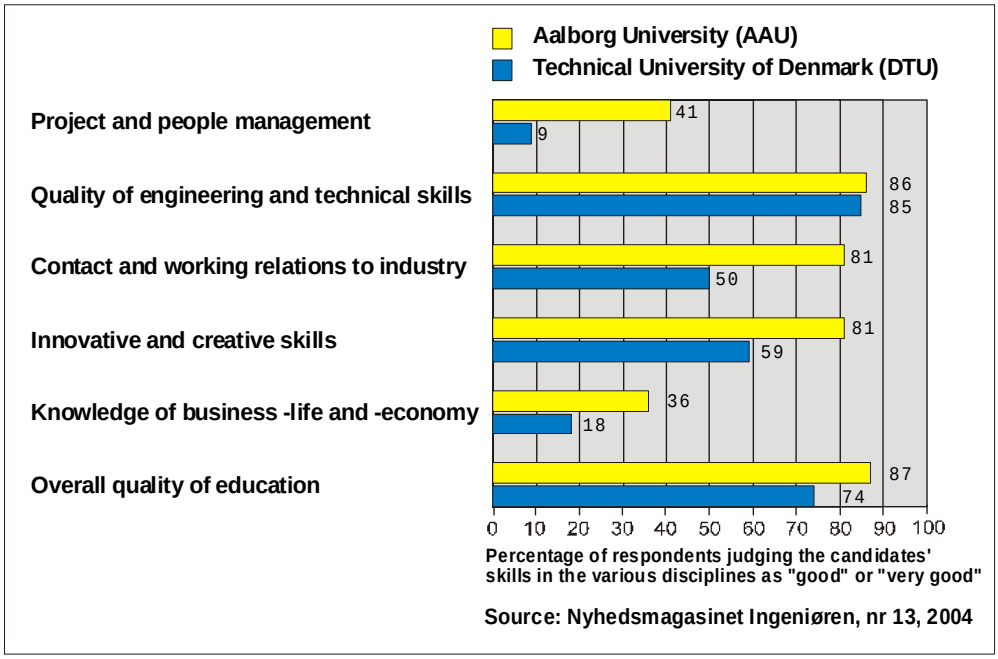

Figure 2: Competences of PBL and non-PBL Engineers in Denmark (Ingeniøren 2004)

In figure 2 is shown the percentage of respondents in the survey who answered 'Good' or 'Very good' when asked about the quality of competences of graduates within the areas indicated in the figure. From the results can be seen that a considerable majority (> 80 %) of companies are satisfied with the competences of the PBL graduates from AAU in the areas of 'quality of engineering and technical skills', 'contact and working relations to industry' and 'innovative and creative skills'. Furthermore, it can be seen that the employers assess competences of AAU graduates as considerably better than those of DtU graduates in the areas of 'project and people management', 'contact and working relations to industry' and 'innovative and creative skills'. Thus, it can be concluded that the competences of AAU graduates are in accordance with what is needed by industry. Furthermore, PBL enhances the entrepreneurial skills of students by allowing them to have experiences of usefulness and success, being allowed and able to solve real-life problems which matters to real-life people.

Brain drain: The introduction of PBL in teaching and learning as well as in research would provide both students and staff with an intellectually challenging, relevant and motivating learning and research environment; thus, it might help stem the 'brain drain' from Africa. A

few quotes from students at Aalborg University serve to illustrate this point as far as students are concerned:

> ”When working on a problem, I am strongly motivated and attracted. We need to solve this problem.”
>
> ”This way of learning is much better than only attending lectures, because I have to know why I need to learn this. When I know the objective clearly, I learn much better.”
>
> ”I think that it becomes easier when you learn technical matters in groups. Normally we use the blackboard to discuss things.
>
> ”Working in groups we get mental support from each other; it is also a responsibility so that we won’t drop out easily.” (Du 2006)

Furthermore, a PBL approach may contribute to the students' sense of ownership; not just of their own education and projects but also of their societies and the country and thus may inculcate in the students a sense of responsibility for the development of these societies as well. This sense of responsibility might in turn reduce the brain drain.

Seen from a Faculty member perspective the intellectual challenge lies partly in being allowed to carry out problem based research, partly in collaborating and learning together with the students working on interdisciplinary real-life problems. The prospect of lifelong learning not only from research but also from teaching, rather than just repeating the same old lecture year after year, should be tempting, as illustrated by the following quote:

> ”Once anyone is involved as PBL-tutor working with students and has the opportunity of seeing what the students can do **when given the permission to think and learn on their own**, he or she usually becomes a convert.” (Barrows 1996, p. xx; emphasis added)

Another aspect is that in a PBL environment it would be considerably easier to make good use of the intellectual capacity of the African Diaspora in the pursuit of higher education than would be the case in a traditional lecture based setting. In PBL African academics living and working abroad could act as assistant supervisor, providing easy access to sources of information which might otherwise be more difficult to access for African students.

5 CONCLUSION

As has already been pointed out above problem based learning is a set of principles based on the constructivist learning theory. In a European context these principles, when implemented in widely different educational PBL models, have proven to lead to better education, especially when measured as the relevance and usefulness of the competences of graduates. In an African context PBL has been introduced in a few universities but substantial documentation concerning the impact of PBL on graduates' competences and the quality of teaching and learning is still missing. Therefore, what be the benefits of introducing PBL in an African university may be remains to be seen - but since there seems to be a general

consensus that changes to education, teaching and learning need to be introduced, why not try the PBL approach, implemented in suitable African PBL model?

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