# Building Computer Graphics Education in Developing African Countries

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## Introduction

Computer graphics is becoming a tool for communication, change, and development throughout the world, and in order for this tool to be effective, there must be an educational base for its use. In southern Africa the development of computer graphics is underway, but is has not made the impact it could have. We believe that one of the main reasons for this is that there has not been as much educational development as is needed in the region. This note will describe some of the challenges that are faced by educational institutions in southern Africa as they try to develop the computer graphics education in the region, and will discuss some of the ways these institutions are working to meet these challenges.

As is the case in any other part of the world, there is a considerable range of educational facilities and opportunities in the region. There are historically strong universities in South Africa, expanding universities in developing countries such as Botswana, Namibia, and Swaziland, and polytechnic institutes throughout the region. While some of the challenges we discuss may apply more to one or to another kind of institution, or even to the special case of an individual institution, they all have an impact at some level.

## 1. Challenges

Developing computer graphics education involves updating and creating courses or course content and, perhaps, removing course content in other areas because curriculum is often a zero-sum game: in order to add something, something else must often be removed. There is always a challenge in making this kind of change to a curriculum, but there are some additional problems when we introduce or expand a topic such as computer graphics into a computer science curriculum in a developing country. Some of these problems are shared by computer science programs across the developed world as well, but are especially difficult in the developing world. We have identified three major kinds of problems, each of which has particular aspects that we will describe.

### 1.1. Student preparation

For many reasons, from limitations in the secondary education that has been available to students to a lack of emphasis on the subject, students come to their university studies with a very limited mathematical background. This is, of course, a problem that is not limited to developing nations, but here it goes beyond limitations in student interest to a limitation in student opportunity. With this lack of background, students have difficulty with mathematical topics and seem to lose interest when such topics come up in computer graphics, as they necessarily must.

A similar problem comes up with programming skill. Again, the limitations in mathematical and other analytic studies at the primary and secondary level leaves students with limited background for programming, which leads to limited programming skill and experience. Computer graphics in the computer science context is quite programming-intensive, and without programming skill it is difficult to focus on the geometric and spatial skills, especially the 3D thinking skills, that students must develop.

With these two preparation problems, there is a significant problem with student motivation. It is difficult to motivate students to study computer graphics on its own because without seeing what can be accomplished with computer graphics, especially what can be done that is applicable to their own lives, students do not develop the passion for the subject that is needed to sustain their learning of sometimes difficult concepts and processes.

### 1.2. Isolation

It is a fact of life in southern Africa, as it is in many other developing regions of the world, that the professionals in the region often suffer from an isolation from the progress and new approaches to problems that may be found in more developed regions. This is part of the classical “digital divide” problem that has such a strong impact around the world. When one works in a field with the rapid changes and constantly-growing ideas of a topic such as computer graphics, this is a critical problem with many aspects.

One problem caused by isolation is that someone working in computer graphics will often have very few people to talk with about the field. In Botswana, for example, there is a group of people at Botswana TV who work with computer graphics, and these are the primary contact for anyone teaching computer graphics in the country. These are good people, but they do not have experience in scientific or engineering aspects of computer graphics, and they do not approach the subject from a computer science perspective, so they provide a valuable but limited set of contacts for education.

New faculty and new ideas are the lifeblood of a growing educational area, but this isolation makes it difficult to have either. This has two very important impacts on computer graphics education. First, without an active community with connections to the developments across the world, it is difficult to create a computer graphics curriculum that is up to date. Courses tend to stagnate and it is difficult to integrate new techniques and technologies into instruction. And second, an isolated community can find it very difficult to attract people to teach in the field and can have difficulty retaining anyone who has made the effort to develop skills in the subject.

### 1.3. Limited support

In order to develop any educational emphasis, there must be a great deal of support for it from a number of sources. There must be a national understanding that it is an important area

that serves national goals, there must be an understanding in the educational institution that the area should have the resources necessary to become a strong programme in the institution, and there should be a public understanding that the public will benefit from the contributions of those who study in the field.

Computer science has recently begun to have this kind of support in developing countries, and university programmes are beginning to get improved facilities and faculties. At the University of Swaziland, for example, laboratory facilities are being rebuilt and new PCs installed, while at the University of Botswana there are good student PC laboratories but these do not have Internet access because it is very expensive and the bandwidth is very limited. Both universities have solid and expanding faculties in computer science.

This support for computer science does not necessarily extend to computer graphics, however. The support for computer graphics in developed countries has been built over the last 15 years from the days when scientific visualization and other graphics applications were seen as ways to make nice pictures but as only marginal to the success of other fields, to the present day when almost all enterprises of any importance include computer graphics as a key part of their development. The key to this changed perception is the 1987 report on visualization in scientific computing [McCormick 1987].

But in developing countries, this support for computer graphics has not yet been achieved. More traditional economies and the limited impact of technologically-based activities make the promise of computer graphics more theoretical than real. And without this support, it is difficult to make the case for increased financial and human resources to develop instruction in computer graphics. Most institutions except the largest will have only one (if any) faculty member who teaches computer graphics, and many institutions are only now starting their first computer science course in computer graphics. Even within education, there is a very limited use of computer graphics in the instruction in other fields or as a component of distance learning.

## 2. Approaches to improvements

While the challenges are significant and in many ways are daunting, there are developments in southern Africa that have the promise of making a very large difference in the importance of computer graphics in the region. We believe that these developments will allow us to see a growth of computer graphics education and application within the next few years that will make computer graphics a major force in the development of the region.

The most important development is the creation of the African Association for Computer Graphics, or Afrigraph [Afrigraph 2001]. This association was created in 2001 with the support of ACM SIGGRAPH and of Eurographics [Chalmers 2001], and its goal is to serve computer graphics professionals in Africa by providing a community of persons in the field, a conference where persons from Africa and persons from other parts of the world can meet to exchange ideas, and a contact for two-way sharing of information between Africa and the rest of the world through relationships between professional associations.

The immediate effect of Afrigraph and of its first conference (at Camps Bay, near Cape Town, South Africa) was to create a great deal of interaction among people from southern Africa and other countries, to share information on the computer graphics activities in the region, and to discuss potential collaborations in research and education. [Brown 2001; Chalmers 2001] In particular, a panel on education, organized by the authors of this paper, generated a great deal of discussion that was the primary source of the ideas we present here. By sharing their experience, computer graphics instructors were able to see that they had common problems and to share ideas on how they might be overcome. In addition, computer graphics professionals within Africa were able to meet new people from other countries and to share their experience—because there is a significant amount of computer graphics activity within the region—with others.

In addition to sharing information at the Afrigraph conference, the relationship between Afrigraph and both ACM SIGGRAPH and Eurographics will help keep open the communication channels between Africa and the rest of the world. By sharing publications and materials from the different associations' conferences, members of all these associations will have a broader understanding of the developments around the world. And by sharing personal connections, Afrigraph can help with the academic exchanges and with the visibility of computer graphics activities that can help develop the skills of current faculty and attract new faculty to the region.

For education, the discussions at the Afrigraph conference provided a number of ideas. It was seen that there could be ways to introduce students to computer graphics without needing so much mathematics that their enthusiasm was lost. Including such innovative ideas as learning drawing skills, students can learn to see spatial relationships. By focusing on some of the practical aspects of computer graphics, students can see the value of the subject and will develop a passion for the subject that can carry them through later studies that are more mathematical. By seeing the value of computer graphics as a way to understand other topics, students can see that the subject has important contributions to other fields. It was generally agreed that computer graphics studies should begin as early as possible, but could not start before the student had developed programming skills, and that there should probably be at least two undergraduate courses, one more practical and based on a graphics API, and the next more theoretical and mathematical. For one possible approach to this combination of courses, see [Cunningham 2000]. There is also an interest in developing educational opportunities in multimedia to take advantage of the ability of computer graphics to support communication and to assist in the teaching of other subjects.

In order to develop the resources needed for education, computer graphics instructors will need to reach out to others to show the value of our subject. We can take advantage of any joint programs in our universities to share our knowledge with other academic programs or other institutions, and in particular we can help faculty from the sciences, engineering, or other areas to address problems in their fields with our tools. When other fields start using computer graphics in their teaching or research, it will increase the motivation of students to study computer graphics and will give us a better case for increasing our financial and staffing support.

Beyond this, though, we have the opportunity to help make computer graphics a key part of the development of our countries and our region. It seems particularly important to use computer graphics to help address the particular problems that

will make a difference to the public and to the government, because this will ensure that our universities will understand the importance of computer graphics education to our national interest. This will need the collaboration of computer graphics with other academic fields as well as with non-academic activities, and will stretch the already-thin computer graphics resources, but will pay large dividends over time.

## 3. Conclusions

There are rich opportunities for computer graphics to contribute to the development of southern Africa. There is untapped talent among students and there are dedicated faculty who care deeply about helping students achieve success in the field. The significant challenges of student preparation, keeping education current with developments in the field, and developing support for the field in the region can be met, and the African Association for Computer Graphics will play a key role in helping computer graphics professionals in the region keep up with each other and with the activities of the rest of the world. When this is combined with focused efforts to have computer graphics contribute visibly to addressing the problems of the region, we are very optomistic about the future of computer graphics in southern Africa and in Africa as a whole.

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