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ON TRAC IN SCIENCE EDUCATION

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ABSTRACT

TRAC is a national programme, the objective of which is to encourage and enable school leavers to enter careers in science, engineering, and technology. This is achieved via several parallel mechanisms, all aimed at making specialised science laboratory equipment, syllabus relevant content, and vocational guidance material available to schools. Funding is provided by industrial partners, particularly the South African National Roads Agency Limited (SANRAL) and the National Department of Transport, whose primary objective is enhancing the opportunities of learners from previously disadvantaged communities.

The equipment and content focus on the physical science component of the school syllabus but the TRAC Programme extends more broadly, seeking to demonstrate the linkages between the different study areas of physical science, biology, geography, and technology and for that matter, everyday life. Within this framework, the programme provides a mechanism for giving learners access to and contact with modern technology as part of the standard school syllabus, rather than in addition to it. This results in learners developing a degree of computer literacy and familiarity with modern technology whilst studying and experiencing the fundamentals of physical science as set out in the South African School syllabus.

Because the TRAC PAC, the central element of the TRAC Programme is relatively portable, no special laboratory facilities are required. Any school with access to a computer, or to one of the regional TRAC Labs, can implement the TRAC Programme, enabling learners to participate in the prescribed laboratory work. With the sponsored equipment and a computer in hand, most of the experiments can be conducted with the most basic of equipment, such as a beach ball, a piece of old guttering, a piece of plastic pipe etc. Detailed TRAC worksheets guide both the learners and the educators through the syllabus, enabling the teacher to assess the learners using OBE guidelines.

This paper provides a brief overview of the TRAC Programme and shares some of its successes and failures in communicating science and technology to developing communities, its involvement in providing some formal content in Science Centres and some initiatives to expand the programme's ability to communicate science and technology to a broader community.

1 INTRODUCTION

1.1 TRAC – A VERY BRIEF HISTORY

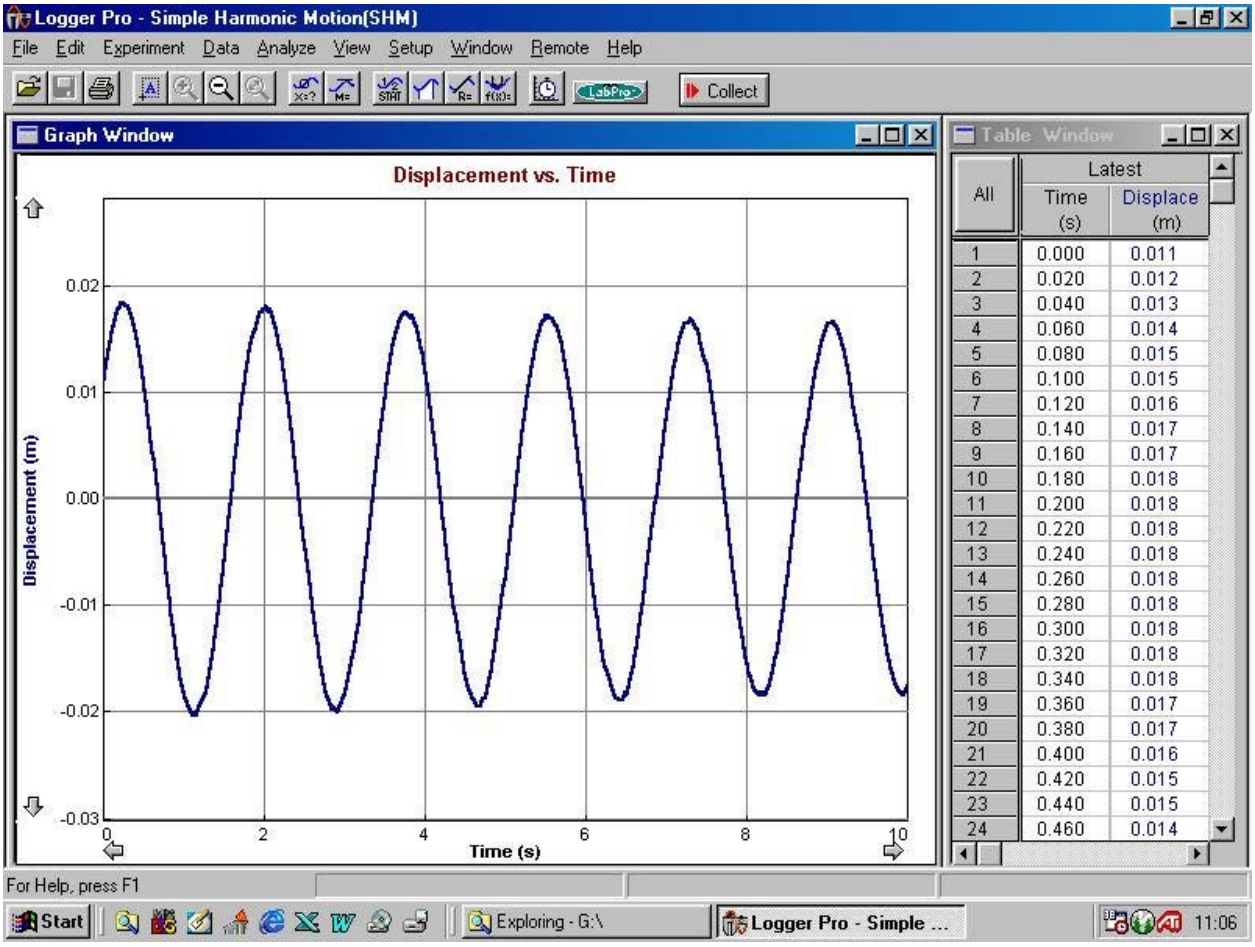
The TRAC Programme was initiated in the United States many years ago as a hands-on outreach programme of the American Association of State Highway and Transportation Officials (AASHTO). In their case, the programme was, and still is, an extra-curricula activity promoting careers in transportation engineering – essentially a public communication of a particular branch of engineering. In 1994, the programme was brought to South Africa in its American format. Initially at Peninsula Technikon, TRAC moved after a short time to the University of Stellenbosch where the TRAC Western Cape Regional Laboratory and TRAC South Africa head office are today.

Since coming to South Africa, the programme has undergone some dramatic changes and grown from a single Apple Mac computer, to a programme with regional laboratories in Stellenbosch, Port Elizabeth, Pretoria, and one in development in Durban. There are also mini-centres in Kayelitsha, Sasolburg, and one in the SUNZONE at the MTN ScienCentre at Canal Walk in Cape Town. Several more are expected to open in various parts of the country within the next six months. About 62 schools nationally currently participate in the programme with their own TRAC PACs and many more participate by visiting one of the TRAC centres. At the same time as growing physically, the Programme has adapted to meet South African needs, as we have learnt from our failures and successes. Before moving onto those, an equally brief look at what the programme offers.

1.2 TRAC PACS

The heart of the TRAC Programme is the TRAC PAC. A TRAC PAC is a set of computer-based sensors and an interface, put together by TRAC SA to meet the needs of the current grades 10 – 12 physical science school syllabus. The equipment is purchased using industrial partner funding and loaned, and ultimately donated, to participating schools for as long as they make regular use of the equipment and provide statistics of that usage. The latest form of the TRAC PAC, as currently supplied to schools, supports 30 of the 50 current experiment worksheets. To carry out the other 20 experiments, sensors can be borrowed from the regional laboratory's "Sensor Library." The sensors can be used in experiments for lower grades of physical science and also for other subject areas, such as geography, biology, and mathematics to some extent, but TRAC worksheets in these areas are still under development.

The sensors plug into a computer via an interface device. The readings of the sensors are recorded and displayed in tabular and, more commonly, graphical format in real time. The user can apply complex functions to the input data, giving much more complex output. For example, the displacement with respect to time of a known mass on a spring can easily be converted to velocity, acceleration, kinetic, potential, and total energy and the relevant graphs plotted out as the mass oscillates. An example of the representation of the basic version of this experiment, at the end of the experiment, is shown in Figure 1.



	Time (s)	Displace (m)
1	0.000	0.011
2	0.020	0.012
3	0.040	0.013
4	0.060	0.014
5	0.080	0.015
6	0.100	0.015
7	0.120	0.016
8	0.140	0.017
9	0.160	0.017
10	0.180	0.018
11	0.200	0.018
12	0.220	0.018
13	0.240	0.018
14	0.260	0.018
15	0.280	0.018
16	0.300	0.018
17	0.320	0.018
18	0.340	0.018
19	0.360	0.017
20	0.380	0.017
21	0.400	0.016
22	0.420	0.015
23	0.440	0.015
24	0.460	0.014

Figure 1: The screen at the end of the basic simple harmonic motion experiment measuring displacement. (During the experiment, the data and graph appear at effectively the same time as the motion is visibly occurring in front of the learners.)

Several factors make the TRAC PAC a valuable teaching aid:

- The results of an experiment are measured and displayed in two formats in real time. Time is not spent on trying to capture and represent the data at the expense of understanding the science inherent in the experiment.
- Learners can redo an experiment as many times as they like and compare the results of all the runs immediately. Once finished with the standard requirements, they can also modify the experiments according to their own interests and interpretation.
- Experiments can be modified very quickly to show more or less information according to the level of development of the learners.
- Learners are exposed to modern technology to which they might not otherwise ever have access. (Many TRAC learners get to use a computer for the first time during a TRAC session.)
- All the experiments can be carried out in an ordinary classroom environment – no special science laboratory area and not much laboratory equipment is required although the better equipped the laboratory, the more rewarding the experience.

1.3 THE TRAC PROGRAMME – HOW IT FUNCTIONS.

1.3.1 TRAC Programme Streams

The TRAC Programme has several parallel streams. Firstly, there are regional laboratories at tertiary institutions. These act as the base for all other TRAC activities including development work. Class groups book sessions in the Labs to do the experiments required in the syllabus. Teachers come to the labs for TRAC and general physical science training. Other teacher training organisations use the labs for occasional work.

Secondly, the TRAC Programme provides sponsored TRAC PACs to schools, along with all the content available. The teachers, trained in one of the regional labs, either use the TRAC PAC to demonstrate the laboratory work, or more commonly, give the learners the opportunity to work in small groups to do the required experiments.

Thirdly, TRAC makes use of facilitators shared with other programmes. These facilitators have TRAC PACs that they take to schools, mostly in rural areas. They then conduct a range of class activities in conjunction with the teachers in whose subjects they specialise.

Finally, the TRAC Programme makes much of its content available via the Internet. This can be used by learners and educators anywhere with some very minor modifications to the worksheets, to allow for the use of standard laboratory equipment. Of course, schools are able to purchase all the sensor equipment for themselves as well.

Irrespective of the mechanism applied in implementing the TRAC Programme, careful records are kept of interaction with teachers and learners and follow up is made to tertiary education institutions to try to establish how many learners, exposed to TRAC at school, have gone on to study engineering.

1.3.2 TRAC Content

Whatever the mechanism used to implement the programme, the fundamental content remains the same. The primary focus, as noted already, is physical science education content in accordance with the standard school syllabus. This material is developed with the purpose of demonstrating the principles and highlighting misconceptions held by learners.

In order to demonstrate the value and uses of science and technology, the TRAC Programme also makes a variety of software available. This is mainly freeware that has been obtained and packaged for distribution to schools and includes Computer Aided Design software, Geographic Information System Software, Bridge design games, urban planning games, electric circuit design and testing software, and a variety of other educational software packages that are interesting, fun and incorporate learning, albeit in the guise of games.

It is all very well promoting science and technology, but learners and their teachers must have some idea of what job opportunities arise from taking an interest in SET. TRAC thus produces a set of vocational guidance booklets focusing on the engineering disciplines. These are available

on order and the last year's edition is available on the Internet, along with our worksheets, as a totally free public service.

2 FAILURES AND SUCCESSES

2.1 SOME HARD LESSONS.

As with all such programmes, TRAC has not been without its failures. We hope though, that we have been able to learn from these and to adapt to avoid repeating our mistakes. Maybe, our experience can help prevent others making the same mistakes. Some of these errors were:

2.1.1 Implementation of a non-South African school programme:

Because something works elsewhere in the world does not mean that it will work in South Africa. The TRAC Programme in the USA focuses on attracting learners into careers in transportation engineering. It relies mainly on volunteers and is strictly speaking, an extra-curricula activity. In South Africa, we aren't meeting the most basic needs in SET education so to be focusing on such a specialised field was ineffective. Restructuring the programme, by dropping the transport focus, to be an integral part of the physical science syllabus acting to reduce, not increase the teacher's workload has solved that problem. It does mean however, that there is almost no relationship anymore between the original and the current TRAC programmes.

2.1.2 Inadequate teacher training and backup support:

In its early years, TRAC provided equipment to schools, but did not have its own training facilities or permanent training and support staff. As a result, either due to teachers changing or forgetting how to use the equipment, a lot of the early TRAC PACs landed up gathering dust or being lost entirely. The lesson was that if you do not keep a hand on the programme by visiting schools at least once a term and preferably two or three times, and ensure that the teachers are properly trained and regularly retrained, resources are wasted. Our regional labs, revised sponsorship agreements, and full time regional managers have helped to relieve these problems.

2.1.3 Inadequate resource density:

We made the same mistake as Telkom, or more correctly, they made the same mistake as us, as we did it first in this example. We provided single TRAC PACs to schools with large classes and / or, far from our ability to provide on site assistance within a couple of hours. The result was that many teachers found it difficult to use the equipment provided, because either they had a problem with setting it up or they could not give all the learners access – a vital requirement to really successful implementation of the TRAC Programme. Innovative teachers in schools with good discipline amongst teachers and learners have had no problems in resolving the access problem – many schools in the target group do not have this discipline however. The main solution to this problem has been to develop "centres of excellence" around which participating schools are clustered. In some cases, these centres are the Regional Laboratories, in others, mini-centres and in a few, areas with self-supporting facilitators.

Using these mechanisms, we are able to establish a base from which local schools are supported, either in the use of their own TRAC PAC or by access to a laboratory staffed by experienced TRAC teachers.

2.1.4 Short term interventions:

There are often science and technology type exhibitions that it seems TRAC should attend. In the past, we have actually done this, but after spending considerable time, money and effort on doing so, have taken a conscious decision to make attendance at such exhibitions the exception, not the rule. There are several reasons for this. The most important from our perspective is that those people we most need to help, are least likely to be at, or if at, to gain any lasting benefit from such events. Rural communities and disadvantaged schools needing help to improve their physical science results are generally overwhelmed by all the activities at science festivals and road shows, but find little to sustain them through the rest of the school year. It is our belief that successful communication of science arises from long-term interventions that provide support to teachers and learners on an ongoing basis and through them, brings science into the community at large.

2.2 SOME POSITIVE ACHIEVEMENTS.

And so on to the good news! In spite of some mistakes and some worrying times, TRAC South Africa has had some noticeable successes and has, by virtue of keeping an eye on the ball, established itself as a significant player in the non-profit provision of physical science education in Southern Africa. Some of the highlights:

2.2.1 Regional Laboratories:

Although even in this area of endeavour there have been some false starts, TRAC is very proud of the fact that it now has excellent working relationships with three major national tertiary institutions, and is in discussion with a fourth. Of particular interest in respect of the public communication of science is the TRAC Laboratory at the University of Pretoria, which is housed in the TUKS Discovery Centre, open to the public and used extensively for a range of educational programmes, several of which make specific use of the TRAC facility. In Stellenbosch, the TRAC Lab is in the Engineering School Centre along with the SUNSTEP Programme and caters for teacher training, open days, winter schools, bridging programmes and of course, regular class groups.

TRAC has received enquiries in respect of the establishment of laboratory facilities from several other tertiary institutions as well, but has been unable to accommodate them all at once, especially with the current institutional mergers placing some doubt upon the future of several universities and technikons. We believe however, that having breached the institutional divide is a significant achievement and we look forward to seeing at least one regional centre in every province within the next five years.

2.2.2 Mini-Centres:

Somewhat less expensive to establish and although not as diverse in function or as generally accessible, another effective way of reaching disadvantaged groups is through the use of mini-centres. The recent establishment of the first mini-centres has given us great hope for the future. One is at COSAT, a school in Kayelitsha dedicated to maths and science subjects for the locals unable to afford other schools. This school gives direct and continuous access to 150 learners from a seriously disadvantaged community and indirect access to thousands more by making its facility and expertise available to surrounding schools.

Another mini-centre has just been set up in Sasolburg, at the Boitjhorisong Resource Centre. This centre reaches out to about 400 farm schools in the Free State, again, offering an opportunity to learners that could not otherwise be provided.

2.2.3 ScienCentres:

Aside from the formal TRAC laboratory in the TUKS Discovery Centre in Pretoria, TRAC is represented in the SUNZONE of the MTN ScienCentre in Cape Town and the establishment of a similar facility at the Gateway, Old Mutual – MTN ScienCentre in Umhlanga is being worked upon. It is hoped to follow this process through in all Science Centres around the country. These facilities are usually run as joint projects involving several complementary programmes offering formal education opportunities within the Science Centres.

2.2.4 Researchers:

One of the mechanisms by which TRAC promotes physical science in South Africa is by acting as a research facility and funding channel for post-graduate education students. There have been two PhD and four master's students on the programme thus far. One is from a top Cape school, (not as a result of the TRAC interaction,) one was head hunted by a university education faculty, one was promoted by the WCED to subject advisor, one is now a facilitator for a sister programme and two are still with us, one in Stellenbosch and one in Pretoria. The fact that TRAC has been able to play a role in the development of these contributors to the development of physical science education in South Africa is considered an important achievement.

3 NEW INITIATIVES

TRAC South Africa constantly seeks to improve its ability to reach out to disadvantaged communities in a sustainable way. Two recent initiatives for communicating SET in the future are worthy of mention here:

3.1 COMMUNITY SET FACILITIES:

TRAC has joined forces with two other programmes, IMSTUS and SUNSTEP and has approached a couple of funding agencies with a view to establishing community science, engineering and technology facilities in conjunction with the regional education departments. These facilities are proposed in areas where the principals and teachers have already been consulted about and are interested in the concept, as, without their support, the facilities will not be adequately utilised to justify the allocation of resources in this manner.

The facilities will be equipped with computers and a variety of science and technology equipment intended to provide educational opportunities to all members of the community. The facilities will support direct school interventions in the area offering support to learners and educators alike. Schools will be able to make use of the facilities, which will also be available for adult education, not necessarily of a formal nature, but rather of practical nature. The SUNSTEP programme for example teaches basic electronics skills, which may be of great interest to entrepreneurial but unemployed adults. The first two such facilities are proposed, one for Atlantis and one for Worcester. Once the concept is established however, the idea is to reach out to more rural communities, establishing centres in as many rural towns around the country as for which funding can be found. It is anticipated that, once established, these centres will form the

backbone of an adult education programme in conjunction with the Construction and Transportation Education and Training Authorities; (CETA & TETA.)

3.2 MOBILE TRAC LABORATORY:

Taking SET to rural communities is an expensive business at the best of times and as a result is often done as a once off exercise, offering no real ongoing support to the rural communities. TRAC has for some time made use of independent facilitators to provide assistance to schools in rural areas. This has however been limited due to the need to suitable laboratory facilities and the problem of transporting to and setting up adequate facilities at rural schools. The use of a pantechnicon, as used by a number of other organisations, has been considered, but discarded as too limited in its reach as well as too expensive to both build and operate given the number of schools that need to be reached.

Instead, we have recently started work on a fully equipped four station mobile TRAC laboratory, complete with its own power supply, which can be towed with a conventional motorcar and thus used by any field worker. The trailer design is such that the trailer will fit through standard double doors and can thus be set up in a school hall or library. Alternatively, it comes with a canopy that can be set up to protect the learners and equipment from the elements.

The hope is that the use of mobile laboratories of this type, equipped with all the standard science laboratory equipment as used by TRAC as well as all the content and vocational guidance material relating to SET careers that TRAC has available, will enable us to communicate several aspects of science, engineering and technology to rural communities at a reasonable cost and on an ongoing and regular basis.

4 SOME CLOSING COMMENTS

Many of you will be asking at this stage, how many learners do we reach – the fact is that the exact number is a guess, but our own counts plus reports from schools, where we are clearly not able to check on the information we are given, indicates that we had about 12 000 formal learner contacts in total during 2000 and 2001. We can also report that about 200 of those learners subsequently registered as engineering students at tertiary institutions although we certainly make no claim that it was as a specific result of interaction with the TRAC Programme. With the establishment of two new regional labs, improved data acquisition methods and some other interventions, the numbers should be both up and more accurate for 2002. The recent addition of two mini-centres, the anticipated establishment of another regional centre and a major advance in our syllabus content development should see the numbers growing very significantly next year

As an initiative of the civil and transport engineering industries in South Africa, TRAC SA has been involved in SET outreach in physical science education using computer technology for nearly nine years. In that time, we have learnt many things; two are of particular relevance in terms of the public communication of science:

- It is nearly impossible for a single organisation to directly reach enough people to make any sort of measurable difference. It is thus necessary to target people who then reach out to another much larger group – in other words; we must reach out mainly to teachers, who reach out to many, many learners, who in turn carry the message home to parents, siblings, and friends.

- The only really effective way of promoting science and technology is to run programmes that are sustainable in the long term and which maintain constant, ongoing, and high quality contact with any community in which the programme is implemented.

The message that I wish to leave today! Making a difference involves long-term commitment, both in terms of manpower and financial resources; anything less than total commitment is a waste of those resources.