

AQUALIBRIUM – Taking the art of learning to international heights



SAICE

Aqualibrium, the water network game first introduced by the South African Institution of Civil Engineering (SAICE) as a schools competition, is gaining international respect as an educational tool aimed at raising awareness around the role and challenges of civil engineering. Lani van Vuuren talked to the game's creator, Prof Kobus van Zyl of the University of Cape Town (UCT), about the game's growing popularity.

Three high school learners are gathered closely around a table. Heads together, they hardly notice the commotion around them as they anxiously watch the thin stream of water move from its bucket 'reservoir' through their constructed network of plastic pipes and connectors. Will this be the day they take first prize? This is the typical experience of a finalist in the SAICE Aqualibrium Schools Water Competition.

When Prof van Zyl developed the game with his students from the then University of Johannesburg (UJ) for the debut of the water competition he never imagined that 11 years later it would have attracted

international interest. "In 2003 SAICE and Rand Water expressed the desire to use an interactive schools water competition as a platform for their combined centenary celebrations," explains Prof van Zyl. The idea behind the competition is to raise awareness of the importance of water supply, the complexity of water supply networks, the role civil engineers play in the process, the application of physics and mathematical concepts as well as the importance of preserving water resources.

The objective of the competition is to distribute three litres of water equally between three reservoirs (containers) placed randomly on a grid of 16 points. Participants build a pipe network between a water source and the three reservoirs using plastic pipes of different diameters. Teams are judged on how well they can achieve this task within a set period of time. To determine the winner the volume of water in each reservoir is measured and penalty points are calculated (teams are penalised for supplying less than or more than a litre per container).

The group with the lowest number of penalty points wins the competition. Competition rules test the creativity of the teams, for example, the main supply pipe has to be connected at point 1 on the competition

sheet; pipes must align with the grid on the sheet, and where two or more pipes meet at a junction they must all be connected to each other. A maximum of eight lines on the sheet grid may be left without a pipe.

SAICE organised regional competitions through their branches across the country, and the regional winners were flown up to the first national finals held at the Pretoria Show. Following the success of the first event, the Aqualibrium competition has become an annual event on the institution's calendar. Prof van Zyl notes that it is largely through the enthusiasm and dedication of event organisers such as Marie Ashpole of SAICE and Lourens Human of Rand Water that the competition got established.

A penalty score below 100 is considered excellent. Interestingly the minimum number of penalty points (and therefore the highest score) ever achieved was 30. This has been achieved twice in the national finals – the first time in 2008 by Brackenfell High School from Cape Town and the second time in 2012 by Port Rex Technical High School from East London.

The 2014 winners, again from Brackenfell High School, achieved a top score of 35 penalty points. The team from Winnie Mandela Secondary School in Tembisa achieved second place, while Dendron Secondary School from Limpopo came third. The three winning teams and their educators shared prize money of just over R17 000. Rand Water again came on board as the main sponsor following an absence of a few years.

Learners experience the competition as great fun and a valuable learning activity. A simple and fun activity, it doesn't matter what your age or level of learning. However, while the competition is simple to understand and fun to do, the underlying problem is highly complex: the three small reservoirs can be placed in more than 3 000 combinations, and potentially there are 280 billion possible pipe networks for each one of these combinations.

Conceptually, the Aqualibrium problem is the same as finding the optimal combination of pipe diameters in the design of a water distribution system. "This is an extraordinarily difficult problem to solve due to the large number of possible solutions, non-linear hydraulic behaviour and discreteness of the available pipe diameters," explains Prof van Zyl.

For this reason, Prof van Zyl introduced Aqualibrium to his third-year civil engineering students at UCT in 2010. The game proved so popular with the students that it has become a standard feature in the course.

Students run the competition under the same rules as the schools competition, however, it is done in a way that integrates closely with course work on water networks. This includes network hydraulics, design and network modelling. "Students are given the opportunity to design the network in advance using hydraulic modelling software, and are expected to calibrate their hydraulic models after building and testing them," Prof van Zyl explains.

A number of final year investigations have also been based on the Aqualibrium competition, including the development of new components, determining the hydraulic properties of components through direct measurement or calibration, and developing optimisation software for the competition problem. Finally, several students have become involved in community outreach as a result of the exercise, taking the competition to schools in their local communities.

Prof van Zyl travels up every year to take part in the national finals, which usually take place at the Sci Bono Discovery Centre, in Johannesburg. "I love the



Kobus van Zyl



Kobus van Zyl



Lani van Vuuren

Top left: Consulting engineering firm Gibb has used the Aqualibrium game as part of their job shadowing initiative.

Middle left: Delegates of the 16th International Water Distribution Systems Analysis Conference in Bari, Italy, get a closer look at the Aqualibrium competition.

Bottom left: Prof Kobus van Zyl explains the rules of the game during the SAICE Aqualibrium school finals.

The Aqualibrium game is enjoyed just as much by girls as boys.



competition because it brings so many complex issues together in such an elegant and accessible way. Aqualibrium deals with our water resources and how we take care of these resources, what civil engineers do and how water gets to people. It also shows learners the practical application of mathematics and science and why they are such important subjects.”

More importantly, he has seen the positive impact the competition has had on learners, students, engineering and the general public. As a result of the competition three students are currently studying civil engineering.

“An important fact to me is that it is not only the privileged schools that can win the competition, but that everybody stands a chance. About one third of our national competitions over the years have been won by very underprivileged schools.” The competition has also seen an increasing number of entries by mixed and all-girl teams – an indication perhaps that engineering is no longer seen as an exclusively male career choice.

The game has gone through several transformations through the years, and Prof van Zyl is always on the lookout to improve its look and feel. The original equipment was designed with common materials so that schools can build their own sets from parts purchased at hardware stores and aquariums. “Originally, the buckets hung under the competition and this required a special board and frame, making it bulky and expensive. Getting air out of the pipes was a big problem,” he explains.

One of the first changes to the system was to have the buckets stand on top of the background, allowing participants to remove the air in the pipes before doing their final run. The next major improvement was the development of an informative, technically correct background for the competition. This was done with the assistance of the UJ graphics department.

Finally, the developers realised the need for more consistent materials to take the competition to the next level. This led to the development of the current equipment using rigid pipes and special connector pieces. During the 2014 competition, take-away Aqualibrium kits were also introduced. These kits come with foldable, material backgrounds and all the network connections neatly fitted into a nifty carry case.


The game has achieved national recognition, having been chosen as a finalist twice in the National Science and Technology Forum and BHP Billiton Awards in the science communication category.

Aqualibrium has also been introduced successfully overseas. It was first introduced to the 14th International Conference on Water Distribution Systems Analysis, held in September 2012 in Adelaide, Australia. This series of conferences brings together the top global experts on water distribution, and is held under the auspices of the American Society of Civil Engineers.

“There was huge interest in the competition at the Australian conference and conference delegates participated with enthusiasm,” reports Prof van Zyl. Some experts used their latest software to try and optimise the system, and in the end a delegate from Belgium won.

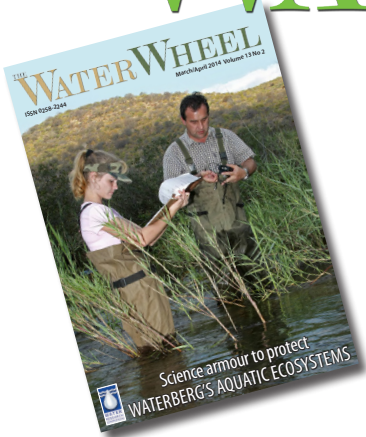
Since then the competition has been run at two further international conferences in Italy. Various people have expressed interest in taking the competition to their own countries, and Aqualibrium is already played in Italy, Austria, the USA and Australia.

Prof van Zyl’s dream is to see Aqualibrium as a true international event. “Our national winners should compete against winners from other countries in an Aqualibrium World Championship that brings together learners to meet, share and spread the message of caring for our water resources.”

To become part of the Aqualibrium movement, visit www.aqualibriumcompetition.net or follow their Facebook page ‘aqualibriumcompetition.’ 

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