SAASTEC

Southern African Association of Science & Technology Centres

Successful Science Shows

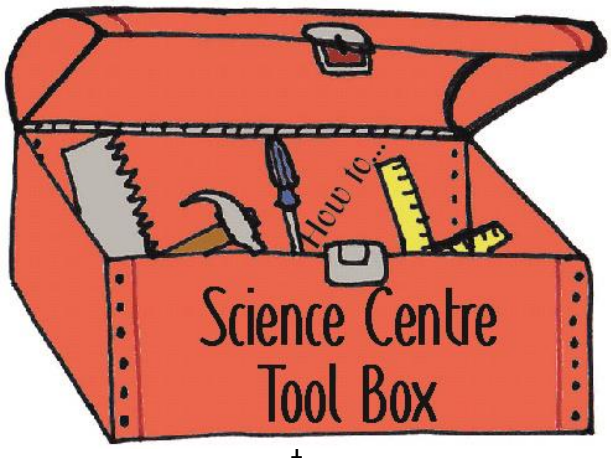
By

Derek Fish

Unizulu Science Centre

This excerpt forms part of the

SAASTEC TOOL BOX



Contents

Introduction

An ancient Chinese proverb states:

> Tell me, I forget; Show me, I remember; Involve me, I understand

This applies especially to science teaching, where these three levels are represented by:

> Lectures ("Chalk and talk"); Demonstrations; Classroom Practicals

Historically we have seen didactic teaching, where an "expert" speaks (and occasionally writes or draws) for an audience of novices; the "Continental Tradition" of expert-led demonstrations and the "Anglo-American" or "heuristic" (discovery learning) tradition of hands on practical work.

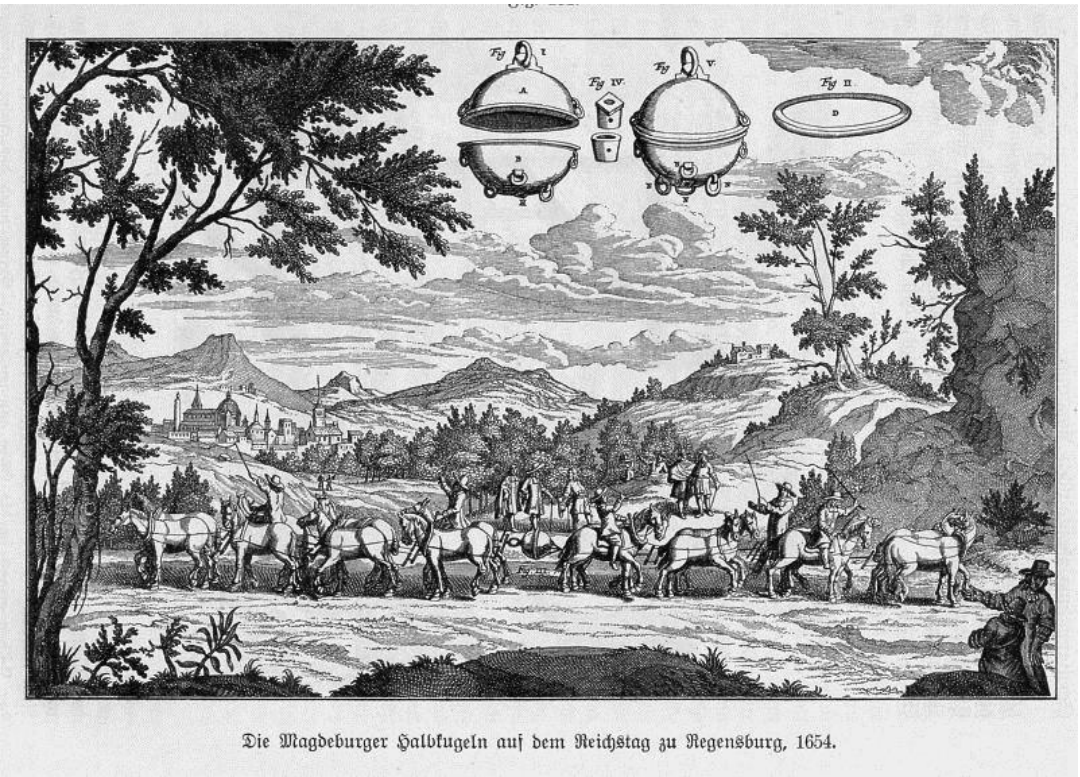
Sadly, in South Africa, science teaching very seldom gets beyond the first (chalk and talk) level and Science Centres (SC) in many ways exist to ensure that pupils (and the general public) are exposed to the second and third levels. It is well known that people remember what they have seen more than what they have heard, and are more likely to understand a process in which they have been personally involved. While interactive exhibits provide the most personal hands-on experience for a visitor, a good science show can involve teaching at all three of the levels above. In summary then:

Proverb	Science Teaching	Tradition	In a science show	In a SC
Tell me, I forget	Chalk and Talk	Didactic Tradition	Explain a concept	Lectures, lessons
Show me, I remember	Demonstration	Continental Tradition	Do a demo	Shows, busking
Involve me, I understand	Classroom Practical	Anglo American or heuristic tradition	Use volunteers or do whole audience demos	Exhibits, Workshops (Shows!)

Shows also have the following advantages over exhibits:

- Shows are *much* cheaper. A room full of exhibits covering a topic can easily cost half a million rands new. A good science show can be put together for a few thousand rands
- Shows are portable and can be taken out to reach wider audiences
- Shows can respond more quickly to current events (e.g. a Tsunami). A new exhibition will take months or even years to produce. A show can be put together in a week.
- Shows stress the human nature of science with a presenter in direct contact with an audience
- Shows can include demonstrations which are not suitable as exhibits, being: too dangerous, too expensive (ito consumables used, or fragile equipment), or too difficult to get right.
- Shows are much more flexible, and a good presenter can match the show to his audience.
- Shows are great training grounds for staff to develop presentation skills
- Shows require far fewer staff members than exhibit facilitation

History of Science Shows



Die Magdeburger Halbkugeln auf dem Reichstag zu Regensburg, 1654.

The picture above shows Otto von Guericke demonstrating his "Magdeburg Hemispheres" to the public in 1654. Once the air was evacuated from the two hemispheres it required 16 horses to pull them apart against atmospheric pressure. This would probably not have been believed without being seen and the impact of this demonstration would live in people's minds forever. Was this the first science show?

The public has attended lectures on science for hundreds of years but Michael Faraday's talks at the Royal Institution in London represent perhaps the first time that demonstrations became a regular feature in these talks. Beginning with the "Chemical History of the Candle" he started the Christmas Lectures which have continued to this day. Early in the 20th Century lecture demonstrations became part of European Science Museums (Deutsches Museum, Munich; Palais de la Decouverte, Paris; Science Museum, London) and still feature there today. With the advent of modern interactive SC's in 1969 (with the opening of the San Francisco Exploratorium and the Ontario SC) shows became a regular feature of SC's programmes and have evolved and grown to what we know today.

Types of Science Shows

Science shows can take many different forms and we should be careful not to constrain the concept too much! These can include:

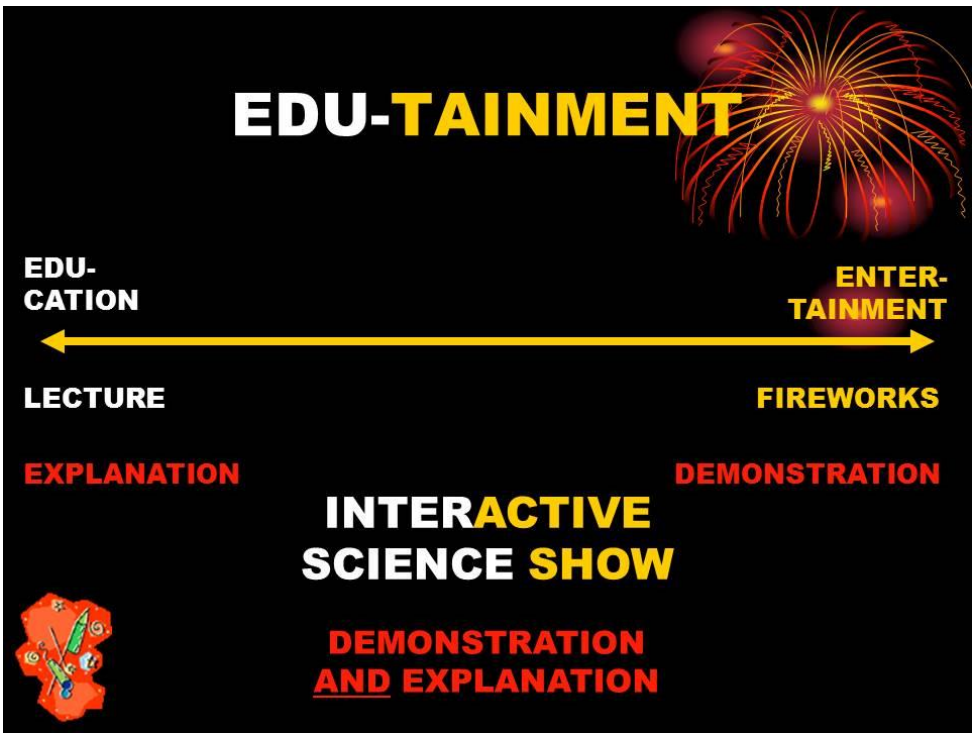
- A formal lecture demonstration on a scientific topic (eg "Waves" or "Refraction")
- An informal fun presentation around a theme (eg "Science of Sport" or "Good Vibrations")
- A loosely linked collection of exciting demonstrations (eg "Science Magic Show")
- A science lesson in a "TV Game Show" format (eg "Who wants to be a millionaire?")
- A "star performer" talking on a topic (eg Mark Shuttleworth on space, Nobel prize winner)

- Informal “busking” activities (Mini-shows for a small crowd on the exhibit floor or in a public place like a shopping Centre)
- An astronomy show (in a fixed planetarium, portable starlab or using Stellarium etc)
- A show based around animals (eg Live shark dissection, projecting a microscope etc)
- Story telling or drama to explain concepts (eg HIV-Aids Show etc)
- … and many more (add your own here!)

There are basic principles for performing an effective show which are common to all of the examples above.

To theme or not to theme?

Science shows basically represent what is often called “Edutainment” – a mixture between education and entertainment. They are more formal than open exhibit exploration, but less formal than a classroom lesson. At the two extremes we would have a lecture, with no demonstrations and a fireworks show, with no explanations. We should strive for something in between



Sadly, many Science Shows (especially Chemistry shows) are presented as little better than Fireworks Shows, with a series of dazzling demos and exciting explosions but little or no explanation given. The effect of such a show on the audience will soon be forgotten. So how does one ensure the correct balance between demonstrations and explanations?

Our school science curriculum is based around two important educational concepts:

- Conceptual Coherence:- theming, or keeping things together that belong together
- Conceptual Progression:- ordering the material so only small steps are required from one concept to the next.

As an example, in Physics, Mechanics is taught as a whole, and progresses from: position – distance – velocity – acceleration – force – work – energy – power. Each new concept builds on the previous one and requires just a small additional explanation to be understood. For maximum understanding, a science show should ideally handle one coherent theme and progress conceptually in small steps so that explanations can be brief and easily handled by the audience. Where science shows comprise an eclectic mix of demonstrations from every conceivable topic, explanations become too complex and are usually just not given! A science show needs to respond to its audience though:

- For school groups, especially all from one Grade, there is an ideal opportunity to present a strongly themed show which will educate and enlighten, without losing out on engagement and entertainment. Being guided (but not constrained) by the curriculum is also helpful for teachers.
- For general public groups (on open days, in shopping malls or at science festivals) the audience will often comprise a range of ages and abilities and learning is not the main priority. Here a more loosely bound collection of demos is often more suitable (and has greater "wow" appeal) but the presenter should still strive to have a story which links the demos together. And don't ever miss out on an opportunity to educate and explain!

Packaging your show

While our shows should always be educational, they must be more exciting than a classroom lesson otherwise there is really no need to visit a SC! Much of this excitement is generated by the way in which the show is presented, or packaged. Some tips to remember:

- "The medium is the message" (Marshal McLuhan). You can't give a 2 hour *lecture* on *creativity*. If we are encouraging curiosity and exploration, the show must contain these elements
- A show is a performance, not a lecture. Make use of drama, dress up, decorate your stage, use lighting and sound effects. Make it a memorable event for the audience!
- Find a catchy title: "Simple harmonic motion and its application in musical instruments" is less likely to attract and audience than: "Good Vibrations! The Science of Sound"
- If you're not having fun, nobody else will. The more you are excited about the show and knowledgeable about the topic, the more you will be able to communicate this to your audience.
- Make good use of humour to keep the show alive, but be aware that cultural differences will affect what is funny and what is not (or what is offensive!)
- The K.I.S.S. principle: "Keep it simple (stupid!)". Don't complicate concepts which are simple by going into too much detail and wherever possible use simple and everyday equipment
- Encourage curiosity and don't always give the answers right away. Allow a little mystery (but not magic) and amazement before all is revealed. Encourage the audience to make a prediction (and get them to vote) *before* presenting an experiment.
- Ensure everyone can see and hear clearly. This is often a function of the venue, but do your best to make sure that sight lines are clear (don't stand in front of your demo) and good sound equipment is used. Discipline problems often start with those who can't see or hear clearly!

- Try to make the invisible visible in your show. Take difficult concepts like vectors, sound waves etc and use props and technology to allow students to see these.

Scientific Method

Apart from assisting understanding, classroom practicals are also essential in teaching students to make use of the scientific method:

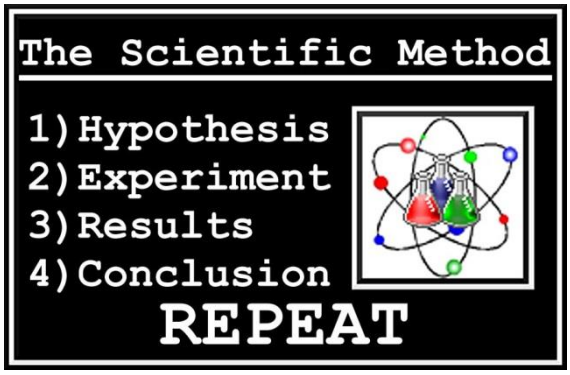
1. Aim (problem to be solved),
2. Hypothesis,
3. Method
4. Results
5. Conclusion.

Sadly this is almost completely neglected in SA schools and unless students take part in the Eskom Expo for young Scientists, they may never learn this essential skill. A science show can be presented in a way which illustrates and demonstrates the scientific method, allowing for discussions and participation. As an example.

1. Problem: A mass-piece is observed to fall very slowly through a copper tube.
2. Hypothesis – students are asked to suggest an explanation. They may suggest:
    a. The masspiece fits very tightly in the tube
    b. The masspiece is a magnet and sticks to the side of the tube etc
3. Method – each student hypothesis is tested using the equipment, and other equipment if necessary to act as a "control" (like a plastic tube of the same dimensions)
4. Results – on the basis of the outcome of the tests, the hypothesis is accepted or rejected. (BUT: use the opportunity to praise the student for a good suggestion, whether it turned out to be correct or not.)
5. Conclusion – either students have come up with a correct explanation, or not, in which case the presenter may finally follow through steps 2- 5 with his own hypothesis.

    2) The masspiece is a magnet and induces a current in the copper tube, taking away kinetic energy and making it fall more slowly.
    3)The masspiece is dropped through a wire coil connected to an ammeter
    4)The ammeter shows a current as the magnet falls through the coil.
    5)An electromagnetic effect (in this case Lenz' Law) is slowing down the masspiece/ magnet

This will of course take much longer than a simple demo, but is a powerful way to encourage the whole audience to be part of an investigation.



Types of Demos

There are even differences to be found in the *types* of demos we present. Wendy Sadler, of SMS (Science Made Simple) identified five very useful categories of demo in her Masters Thesis. (Sadler 2004)

Demonstration Categories by characteristic

Category code	Category name	Definition	The audience…?
C	Curiosity	Something weird, a piece of equipment never seen before, something counter-intuitive, a challenge to the audience	Are surprised
H	Human	A volunteer is used, all of the audience take part in an experiment, something personal is learnt, something funny happens to volunteer	Interacts
A	Analogy	A visual representation of something that is usually invisible, using body language to draw a mental picture, using models	Understands
M	Mechanics	How things work, taking things apart and seeing what is inside, how the science is applied in real life things, how to make simple things, in general applied science – technology	Contextualises
P	Phenomena	A chance to see a scientific phenomena happening live, may use equipment not readily available, not necessarily weird, illustrates the basic science using a demonstration rather than words	Experiences

She then looked at the short and long term memories of these demo types, finding that the CURIOSITY demos have the longest retention in a student's mind. There is much more of value to look at in her thesis, her final advice being: "Based on this research it is recommended that science show professionals ensure a mixture of the **CHAMP** demo categories within their presentations as there is evidence to suggest different types of audience respond to different categories of demonstration."

I believe this "CHAMP" analysis provides a very useful framework for looking at our shows.

Consider your audience

Although it is useful to gather ideas from other presenters, any good show needs to be tailored to the audience. Some of the differences you may need to consider might be between:

- Male and female students
- Rural, urban and township students
- Cultural differences (eg attitude towards authority, questioning)
- Government, former model-C and private schools
- English, Afrikaans and isiZulu speakers (or whatever languages you encounter)
- Wealthy and poor students
- Technologically literate (computers at home) and illiterate students (no computers)
- Different age groups (pre-school to University)
- Science and non-science students (often mixed up in one group)
- Students of differing intellectual ability
- … and many more (add your own here!)

These will obviously affect many aspects of your show:

- The *content* of your show (are boys and girls equally excited by "The Science of Soccer"?)
- The *language* you present in
- The *duration* of your show
- The *conceptual level* of your show
- The *pacing* of your show (how fast you can proceed) and therefore
- *How much material* you try to cover in the show.
- The *applications* you give for the concepts in the show. (Do all understand "bungee jumping"?)

The best presenter will be sensitive to the needs of his audience and will adapt the show for their maximum enjoyment and understanding. Constructivist theory tells us that students come to our Science Centres with pre-existing ideas of how the world works. When confronted with conflicting ideas from science they are forced to make a "border crossing" (Aikenhead, 1996) from the familiar territory of their cherished beliefs into the "unknown country" of science. How difficult this crossing is and how comfortable a student feels to remain in this new country depends on many factors both internal and external to the student. The challenge for our Science Centres is to assist students to cross these borders more easily and to remain in their new country without feeling threatened.

Audience Participation

The trick to upgrading a show from "show me, I remember" to "involve me, I understand" is audience participation. It also emphasises science as a human endeavour involving cooperation between many people. Discipline problems will also be far fewer if the audience are active participants in the process. The main forms of audience participation are:

Whole audience demos:- Getting the whole audience to "volunteer" by doing something in which everyone can be involved (eg "all put fingers on throat and sing to feel vibrations from the voice box, make a Mexican Wave" etc). One can also ask for voting as to the outcome of a demo, or for opinions on an issue (HIV-Aids, global warming etc). If one has access to remote clickers, this voting can be far more quantitative and can provide data for research projects as well. The audience can also participate in a

"thought experiment" or do calculations in a mathematics show. Try to include at least one whole audience demo in each show.

Volunteers:- Students usually love to come to the front in a show, although this is often more true for primary schools than for teenagers. Some points to consider when calling for volunteers:

- Try to ensure the volunteer will be able to do what is required so as not to make them feel like a failure (don't invite an overweight child to touch their toes in your sports show!)
- Ensure that what they will be doing is safe
- If you may have to touch the volunteer (eg catch them if they fall while spinning) ensure they are the same gender as you
- Make them feel special by applauding their arrival and departure, and by using their name
- Keep them on stage only as long as they are needed – don't leave them hanging

Questions:- these are an excellent way of involving the audience and encouraging enquiry and interaction. Sadly, though, questioning does not happen much in schools (as it is not encouraged by teachers) and you will have to work hard to get audiences involved – especially from rural schools. Make sure that you pause at various points in the show to invite questions form the audience – they will not remember their questions till the end of the show! Encourage question *asking* (I give prizes for good questions asked!) and stress how important it is in learning science. Feel free to move on though if the questions become too many!

When asking questions of the audience, avoid parrot-fashion recall questions which will make the show feel like another class or like a test! Try to use predictive questions ("I wonder what would happen if we …") or questions that relate demos to the real world ("Can anyone think of where they have seen this used in their house?"). If a show necessitates a lot of information, end it with a quiz with prizes as an incentive for the audience to concentrate (and tell them about it up front!) When students do answer your questions, be very gentle in how you handle their answers: never reject them outright, but encourage them for trying – while still moving on to the correct answer – either from another student or provided by you.

Science Show Equipment

Without demo equipment, a science show is just a lecture! Sometimes the largest part of preparing a show is preparing and sourcing the equipment, and this will cause the biggest delays as it will probably not be available locally. You may design an entire show in theory, and then go looking for props, or you may build a show's story around an exciting set of props and demos you already have. Usually the two will develop side by side. Remember that standard lab equipment will usually be too small for a large audience, although cameras and projectors can be used to make small things visible. All too often science shows are expected to be "zero-budget". SC's must invest time, money and quality people in ensuring the success of shows. Make your props large, colourful and exciting for maximum impact, but ensure you also do a few demos which the audience can try at home, using everyday objects. To keep track of the structure of a show and the equipment needed, we create a spreadsheet like the one below for a pressure show. This is especially helpful when taking a show on the road to make sure you have everything with you. Take special note of consumables (vinegar, balloons, eggs etc) which will have to be replenished continuously. You might find something similar useful:

PRESSURE		SHOW			
REF	**SECTION**	**DETAIL**	**DEMONSTRATION**	**EQUIP 1**	**EQUIP 2**
(G9)					
2.1	DEFN OF PRESSURE	Pressure as prop to F/A	Nail Chair	Nail chair	Stool
			Balloon Guillotine	Guillotine	Balloons
2.1	UNIT: THE PASCAL	1 Pa = 1 N/m2: *Small* unit	Paper pile	Ream of paper	
2.1	P IN **SOLIDS**	P due to g, directed down only	(as above)		
2.2	P IN **LIQUIDS**	ex in all directions - DOWN	hole in base /PASCO	Plastic bottle	Bucket
		- SIDE	holey ball /PASCO	Rubber ball	Bucket
		- UP	cork / PASCO	Beaker	Cork
		prop to depth	Pascal's vases (comm ves) / PASCO	Comm vessel	
			3 hole cylinder	3 hole cylinder	Bucket
		prop to density	egg and salt (Cart diver ?) / PASCO	Beaker	Egg
2.3	USING PRESSURE	Pascal's Principle	PP apparatus ? / Car Jack	PP app/Car Jack	
		incompressibility of liquids	Syringe / pump	Syringe / pump	
2.4	P IN **GASES**	gases compressible	syringe	Syringe / pump	
		can exert force	blowpipe and stomp rocket (gun?)	blowpipe/stomp rocket	
		kinetic theory	3D demonstrator	3D demonstrator	Beads
2.5	ATMOS. PRESSURE		crush a can / PASCO	Burner and tongs	Shallow dish
			rubber suckers (drain plunger)	Suckers (4 - big & small)	Plunger/s
			Har bottle	Har Bottle	Balloon
			glass and card	Glass	Plastic card
			bottle and holes	Plastic Bottle - holes	Bucket
			lift "magic" bottle	Plastic bottle - no base	Bucket
2.5	MEASURING PRESSURE	Aneroid barometer			
		Mercury Barometer			
(Gr11)					
14.3	BOYLE'S LAW:	Press inv prop to vol	coke fizz / PASCO	Coke can	
14.6	CHARLES' LAW	Press dir prop to temp	exploding coffee tin / PASCO	Burner and tripod	Coffee can
			love meter	Love meter	
(14.7)	VOLUME TEMP LAW	Volume dir prop to temp	candle lifts water / PASCO	Dish and beaker	Candle
			sticking glass	Glass	

Science Show Safety

An unsafe show is never acceptable – even if nothing actually happens. Ensure that both you and your audience (especially volunteers) are safe at all times. *Model* safety by wearing the correct equipment (goggles, gloves, lab coat, hearing protection etc) at all times even if you are confident to do the demo without them. Use the opportunity of the show to discuss safety issues and the science behind them. Don't encourage dangerous behaviour as being cool. Be aware of obvious dangers (from explosions, high voltages etc) as well as matters of hygiene (many kids blowing the same kazoo, wearing the same ear plugs for eg.). Be aware that volunteers or audience members may react in an unpredictable way to a demo which may scare them (loud bang, bright flash etc) and be prepared. Be aware of tripping hazards and events during the show (egg on the floor, spilt water etc) which may be a danger as people exit.

Venue

So much of the effectiveness of a science show depends on the constraints of the venue. The best presenter in a bad venue will still struggle to excite an audience. Every SC should prioritise the building of a custom-made auditorium for science shows where these shows can ideally be left set up for their duration. Some considerations in designing such an auditorium:

- Most architects will have had little or no experience of science shows and will not know what is needed in a good auditorium in a SC. Use their designs with care and feel free to change them to suit your needs. Remember you are employing the architect!
- The best auditoria will have raked (sloping) seating so that everyone has clear sight lines from every seat. The slope is often governed by practical constraints (roof height, safety) but should be as steep as is practical and comfortable. This is expensive to build however. If seating is sloped, there is no need for a raised stage in the front.
- If your only option is a flat room, build a small stage at the front to raise the presenter, but be aware that demos done on a table will then only be seen if they are at the front of the table.
- Carpet in the seating area helps to absorb sound and avoid echoes. The demo area (stage) must *not* be carpeted as this is illegal for an area where chemicals are used.
- Provide a large screen for a data projector and mount the projector as high as possible in the roof so that it is not blocked by the presenter (or shines in his eyes). Use a remote clicker so that you are not tied to the computer.
- Preferably use movable demo tables so that the stage area can be flexible. Extension cords and portable gas bottles can provide electricity and gas to these.
- Ensure there is a sink in the room where water can be supplied and disposed of.
- Check safety requirements very carefully: exits and signs for the number of people, fire extinguishers, emergency lighting for power cuts, ventilation especially when doing chemistry etc.

Evaluation

There are three important levels of evaluation for your show:

1) Your gut feeling and the audience's response (or boredom) will tell you a lot about how the show is working (or not working). Be aware of cultural differences here though and don't expect everyone to jump up and down:- an audience might sit quiet and unresponsive as a sign of respect because your show is so good! You will see what works and what doesn't work by how the audience responds. This will tell you a lot about enjoyment of the show but not necessarily about what was understood from the show.

2) A formal evaluation of the show, preferably using multiple modes of question (MCQ, written, interview, drawings etc) can yield valuable insights into understanding – especially if both pre and post tests are done. Questions need to be carefully chosen though and should ideally be piloted and revised before use. Most educational studies in the literature have been done overseas and have only partial relevance to the SA context. Three studies done (at least partly) on SA SC's which are useful are:

- Walker et al (2011) – a study of an HIV-Aids Education Show at Unizul SC
- Sadler (2004) – a long term study of a sound show in the UK (referenced above)
- Fish (2013) – a study of different school groups' response to a sound show at Unizul SC

3) Feedback from other staff members and fellow presenters is invaluable and should be sought regularly – especially at the start of a new show. This is the equivalent of the "peer-review" process for scientific papers and is essential to make progress. People often shy away from this as they don't want to upset presenters (or to receive criticism), but it is a very necessary part of our growth. As long as feedback is constructive and focuses on what can be improved (not merely what is wrong) it will always improve a show. Other presenters will see things you don't and pick up on opportunities to improve the show which an audience would not be aware of.

Science Shows: a work in progress

Most importantly, remember that a good science show is never complete. As you research and present the show and interact with other presenters you will find many new and exciting ideas which you can incorporate into the show. Often an audience question or comment can lead to a new discussion or demo in the show. Evaluation of the show can give useful feedback which can help you to improve it, or to adapt it to different audiences. As the world changes and new issues become topical, incorporate these into your shows to keep them up to date. Often all that is needed is repackaging of an existing show to keep it current and exciting:- the basic science stays the same. As stated before – this is much easier to do with shows than with exhibits!

And finally – HAVE FUN! Science shows are *never* boring as the audience is different every time. The more you enjoy yourself, the more your audience will. Researching, creating and performing science shows is definitely the best part of my job!

References

Aikenhead, G. (1996). "Science Education: Border crossing into the subculture of science." Studies in Science Education **27**: 1-52

Sadler, Wendy J (2004): Evaluating the short and long-term impact of an interactive science show, Masters Thesis www.**science**madesimple.co.uk/files/**impact**_of_**science**_**shows**.doc

Walker, Graham J., Stocklmayer, Susan M. & Grant, Will J. (2011): Science Theatre: Changing South African Students' Intended Behaviour Towards HIV AIDS, International Journal of Science Education, Part B, DOI:10.1080/09500693.2011.633939

Fish, Derek B (2013): Naïve Conceptions and Mental Models of Sound developed by Students from Diverse Educational Backgrounds during a Science Centre Show, Masters Thesis, (Unpublished, but papers to follow, and material available on request)