

The Chemedian brings laughter to the chemistry classroom

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The Chemedian Brings Laughter to the Chemistry Classroom

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Introduction

The comic strip genre has not been altogether welcome in the classroom, with a long history of comics being viewed by adults as a poor substitute for literature (Fenwick, 1998; Millard & Marsh, 2001). As a genre, they are perceived as low brow, being neither art nor literature and they are condemned for their outlandish use of fantasy (Locke, 2005). Criticism of the portrayal of gender roles or violence has been levelled at commercially available comic strips (see for example, North, 1940). This tradition of viewing comic strips as suboptimal reading material means that many teachers are inclined to exclude or limit the use of comic strips as teaching aids. Nevertheless, it has been argued that reading of comic strips may, by familiarising children with the periodical format, facilitate the move into mainstream non-fiction periodicals, including newspapers and other informational texts (Millard & Marsh, 2001).

Others have argued that comic strips and picture strips, their often non-comic relatives, can be used effectively to provoke thinking about science and health related issues. From a historical perspective, Noakes (2002) reviewed Victorian issues of Punch (1841-1871) and found that the comic format was frequently used to present scientific topics. Noakes (2002) argues that the comic treatment of science may have played a significant role in the education of adults about scientific developments. More recently, a study involving South African teenagers found that comic strips and graphic novels can stimulate people to think about science and health issues (Kruger, 2001). Research carried out with Action Magazines, which use a comic format to introduce children in developing countries to environmental and health issues, suggests that the format can be used effectively in the classroom (Russell & Murray, 1993).

Different but complementary use of comic formats includes the use of single frame cartoons. Humorous cartoon drawings have been shown by Naylor and Keogh (1999) to promote discussion of the scientific basis of phenomena amongst both children in the classroom and adults travelling on the London Underground. One example of a subject featured in what they named "concept cartoons" was whether putting a coat on a snowman would affect the rate at which it melted. The cartoon features three characters each of whom has a different view and the question directed at the viewer is "What do you think?" It is clear from these projects that humour can be used to draw on the wider cultural milieu and engage children.

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Interest plays an important part in children's motivation to learn and several studies have shown that children enjoy reading comics (Worthy, Moorman & Turner, 1999; Dungworth *et al.*, 2004). Worthy, Moorman and Turner (1999), for example, found that light materials, including comic strips, topped the list of preferred reading materials for 6th Graders (12-13). Bespoke comic strips, which draw on a popular cultural form but contain controlled, curriculum linked content, could be used in school to harness this interest and provide an additional means of stimulating children's interest in science. Year 5 girls enjoy reading more than boys (Dungworth *et al.*, 2004). This study found that pupils preferred books to other forms of written media. However, more boys read comics (40% compared with 22% of girls). In terms of genre, adventure stories and humour were most popular. Both are genres commonly employed in comic strips.

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Why Use a Comic Strip to Communicate Science?

The old cliché is that a picture says a thousand words. That may not be entirely true, but it is possible to convey scientific principles using a combination of visual imagery, humour (both visual

and textual) and narrative. This combination of methods seems likely to convey a concept more easily than words alone. Hughes (1998) argues that visual images can help children understand concepts, such as change by depicting, for example, what happens to a scene over time.

Several authors propound the use of narrative as a means of communicating science and many students acknowledge the role of narrative in kindling their interest in science (see for example, Negrete & Lartigue, 2004; Kubli, 2001; Strube, 1990). The concept of narrative in science education is not new. The late 19th Century saw many approaches involving the use of fictional stories to engage children in the science curriculum. However, as science became a more established discipline, science textbooks were written and in the early 20th Century the textbook became the standard approach to teaching science. Strube (1990) notes that science is rarely taught with narrative in mind, but from a pragmatic paradigm where scientific knowledge is applied to a specific situation. This, he argues, means that science teaching does not draw on the “creative content of the mind”. It may also lead to decontextualisation of learning which makes it hard for pupils to extrapolate scientific principles to new situations. Narrative can be used to reinforce concepts by, for example, allowing an exploration of what the world would be like if a particular scientific principle did not hold. In this way, a connection between the scientific principle and the real world can be drawn and reinforced. Furthermore, Strube (1990) argues that narrative stories are often more memorable than factual detail. Thus, careful use of narrative may aid learning.

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In the US at least there is a growing cultural movement toward acknowledging the importance of narrative and personal meaning; this may contrast with a traditional focus on logic in the science classroom (Applebaum & Clarke, 2001). Applebaum & Clarke (2001) also point to the need to set up a classroom rich in possibilities, rather than focusing entirely on science as understood by adults. While these authors do not advocate making science ‘fun’ the approach would suggest that drawing on a range of cultural genres would open up opportunities for children to explore science in unconventional ways.

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“The Chemedian and the Crazy Football Match”

This project draws on genre familiar to many children and adults – the superhero comic. The main character – The Chemedian – could be seen as a superhero, though one that draws on more recent developments in this genre (she is female, a rebel, a bit naughty and has ‘magical’ powers). The character also draws on what Locke (2005) defines as the science-magic constellation. She is clearly a magical character in that she comes from another dimension and can control and modify scientific properties at will. These powers, however, also clearly root her in the scientific domain and she uses these powers to draw readers into thinking about the importance of science to the way we live our lives. Readers are invited to consider the implications, for example, of playing football on a pitch made of ice, particularly if the pitch turned to ice in the middle of a game.

The use of a full length comic strip, as opposed to single frame cartoon images, has the potential to combine a powerful narrative with striking imagery. Narrative is a powerful way of highlighting the consequences of science for the characters in the story and is used to draw pupils away from the pitfall of believing that science is merely a collection of arcane facts. The Chemedian comic strip uses this approach to reinforce aspects of the primary chemistry curriculum. In the case of this particular comic strip, the Chemedian alters the properties of materials, often with dire consequences for the characters in the comic strip. These consequences are depicted visually for heightened effect (see Appendix 1). Thus, if you change a football pitch into an ice rink, all the players slide and fall down – a visually funny scene and one that is recognised by children who have enjoyed slipping and sliding on patches of ice. Similarly, if you replace the elastic holding up

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2 players shorts with string, the shorts fall down – causing embarrassment to players and hoots from
3 children. Combining these visual jokes with carefully constructed narrative that allows the
4 character to wonder what will happen’ further draws children into thinking about the way the world
5 works and highlights the exploratory nature of science.
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8 *Comic Strip Creation*
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10 | The original concept was first audience-tested in the form of a play conceived by one of the authors
11 [initials here] and performed at the Cheltenham Festival of Science in 2003. Evaluation showed
12 that audience members found it a novel and interesting way of learning science and that they would
13 be interested in having similar experiences in the future. A second play featuring the Chemedian
14 character was then commissioned by Cheltenham for the 2004 Festival and the resulting script
15 became the starting point for the devising of the comic strip. Observational data collected at these
16 performances clearly demonstrated that children liked the character and engaged with the
17 performances (unpublished). One aspect of the decision to experiment with a comic strip version of
18 the story rather than mounting further performances of the play was based on the realisation that the
19 comic strip would have the advantage of being less expensive and easier to disseminate, whilst
20 possibly offering greater opportunity to ensure consistency of message.

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21 | A 35-frame, 6 page full colour comic strip was created (See Appendix 1). The comic strip was
22 written and conceived by one of the authors [initials here] and illustrated by a professional
23 children’s illustrator [name removed]. In developing the comic strip, attention was paid to
24 producing a comic that fit the ‘super-hero’ genre while allowing the researcher the opportunity to
25 control the content and narrative structure of the story. Thus, an ‘off the shelf’ comic would not
26 have been suitable for this project because it would have been unlikely to find a comic that
27 contained specific linkage to the UK primary science curriculum. The comic strip developed relates
28 to the unit of study in the national curriculum for England and Wales identified as ‘Materials and
29 their properties’. Aspects of this unit are covered in all years of the primary curriculum so the
30 majority of children participating in the study would have had some exposure to the topic before
31 the comic strip was tested. (At one school this research project was used to introduce this topic.)
32 The scheme of work includes consideration of the fitness for purpose of materials (e.g. why certain
33 materials are used for specific tasks). The comic strip drew on this particular aspect to demonstrate
34 what happens when the wrong material is used for a particular purpose.
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36 Within the comic strip, the following changes to materials were made:

- 37
38 • Change of football into a balloon
39 • Change of football pitch into ice rink
40 • Change of elastic in players’ shorts to string (untied)
41 • Change of metal goal post into cardboard (so Chemedian could lift it up and allow a goal in)
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43 **Methodology**

44 *Preliminary Concept Testing*
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46 Three illustrators were commissioned to create character concepts for the comic strip based on a
47 written description of the character. This description was derived from the character developed for
48 the theatre performances and included key features such as:
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- Female, about age 10
- Naughty, impish, a rebel
- Magical, from another dimension
- Someone who makes chemistry funny

The three concepts were tested in a mixed year group primary school class (30 pupils, ages 7-9). As well as a general discussion of characters and comic strips, children were specifically asked to identify the character they liked best and the character that they thought would have the best adventures. On the basis of these findings, a character was selected and an illustrator commissioned to create the full length comic strip.

The same group of children were also shown black & white rough drawings of the comic strip at the development stage and asked to comment on any illustrations they did not like and specifically whether the characters should use vernacular English or 'correct grammar'. On the basis of this feedback, minor amendments were made to the comic strip and the final version was produced.

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Comic Strip Evaluation

School and class characteristics

Five primary schools in England were recruited to participate in the research project. These schools represented a range of different types of schools:

- Small village schools, with mixed year classes (2 schools)
- A large village school serving a turbulent catchment area (RAF base)
- A foundation school (selecting pupils on the basis of religion)
- A school with a turbulent catchment area, below average achievement and wider family literacy problems (two classes were involved from this school)

Within these schools the following year groups were involved in the project:

- A year 3 class (7-8 year olds)
- Three mixed year 3-4 classes (7-9 year olds)
- A year 4 class (8-9 year olds)
- A year 4-5 class (8-10 year olds)

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Baseline vocabulary

Children were asked to play a game 'the Alien Game' as a means of establishing their baseline vocabulary related to the properties of materials. The game involved children working in pairs to describe an object (either a piece of string, a piece of elastic, a piece of metal, a piece of Velcro or a piece of wood) to an alien who did not know what the object was. Children were asked to write their description down without naming the object.

Comic Strip Analysis

Children were then asked to apply stickers to the frames and words as they read the 6 page comic strip. Children were asked to apply a blue sticker to anything they found funny or that they liked

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2 and a red sticker to anything they did not like or did not understand. Instructions were given
3 verbally and also provided on the whiteboard.
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5 While the children were undertaking this task the researcher and an assistant asked children
6 individually about the comic strip and why they had applied stickers to particular frames or words.
7

8 *General Discussion*

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10 Finally, the class was brought together for a general discussion of the comic strip. This included
11 questions relating to the ‘tricks’ the Chemedian had played in the comic strip (e.g. why don’t we
12 play football on ice?) and more general questions about the character and what she was doing
13 (What would the Chemedian do in your classroom? Who would be the Chemedian’s friend?).
14

15 *Teachers’ Impressions*

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17 Teachers’ were given a notepad and asked to record their observations of the class as they
18 undertook the three tasks. This included a request to note any unusual or surprising behaviour and
19 specifically whether the class was working well or poorly at the task. (Two teachers were unable to
20 complete the observations because they needed to support pupils with particular special educational
21 needs). In addition, semi-structured interviews were held with all teachers following the sessions.
22

23 **Results**

24 *Character Development*

25
26 It was clear from the preliminary research that one character was strongly preferred (see Table 1).
27

28 **Table 1 about here**

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30 Asked to describe their favoured visualisation, the character created by DS received comments such
31 as:
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- 33 “She’s brilliant.”
34 “We like her because of the skateboard and just the clothes she’s wearing.”
35 “She’s cool.”
36 “I like the colours, bright colours.”
37 “I like her face and hair.”
38 “She looks wicked”
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41 This character was chosen for development of the full comic strip. In addition, the preliminary
42 research indicated that children would prefer a comic strip that used language that reflected the way
43 that they speak rather than focusing on correct grammar.
44

45 In order to learn more about what children find funny in the comic strip format, children were given
46 a series of excerpts from commercially available comic strips (e.g. Simpsons, Tom and Jerry,
47 Beyblades). The children were asked to identify the comic they liked best and to describe what they
48 liked about their chosen comic. From their responses, it was clear that recognition was important in
49 their choice as was a feeling that the comic was “funny”. The category “funny” included aspects
50 such as: characters, dress, words and actions.
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About the Simpsons one child said, *"they are funny and they have funny characters and they say funny things"*

A one page comic about Roman baths received the following comments, *"It's funny. It's funny how they are drawn. It includes funny facts, but the topic isn't very interesting"*

This latter comment suggests that children can find the representation of a topic funny even if they don't find the topic itself intrinsically funny.

Vocabulary Assessment

The Alien Game was used primarily to assess whether students had a suitable baseline vocabulary from which to discuss the properties of materials. In 5 of the 6 classes, children were able to use appropriate vocabulary to describe their object (e.g. hard, stretchy, sticky). However, in one classroom (mixed year 3-4, underperforming school), children found this activity difficult and analysis of their responses indicated a very limited vocabulary. During the session with this class, it became evident that many of the children were not able to read the comic strip. For this reason, it was decided that the comic strip would be read aloud and the children asked to follow the pictures.

What Children Liked About the Comic Strip

Children clearly enjoyed the comic strip. More than twice as many funny/like stickers (2517) were applied to the comic strip than negative stickers (1101). In addition, many children were observed smiling or laughing while reading the comic strip. Comments collected from children while they were reading the comic strip include:

"Well cool. I like the football match and the trousers falling down bit." - pupil from year 3/4 class

One boy commented about the Chemedian,

"She's cheeky and quite funny, sarcastic. I like her and wouldn't change her" - year 3/4 class

Children were also asked whether they would like to read something like this again. Of the 118 pupils asked this question, 97 responded that they would like to read something like this again¹.

Although the majority of children enjoyed reading the comic strip, some clearly found the format and/or story less appealing. Of the 157 children who returned sticker-covered comic strips, only 5 children had applied more negative stickers than funny/like stickers. One pupil summed up this view:

"It's not really funny, none of it" - pupil from year 3/4 class

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¹ Pupils in one class were not asked this question owing to time pressure.

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Table 2 about here

Figure 1 about here

Children’s Dislikes

Children identified four frames that they did not like (as judged by an excess of negative stickers over funny/like stickers). These frames include a text box explaining where the Chemedian comes from, the first frame showing the football match and two frames that led up to the Chemedian turning the football pitch into an ice rink. Analysing these frames in more detail showed that the text box received few stickers at all and, as this is an explanatory box, it was not intended to be funny. The negative stickers may reflect children’s preference for action:

“There’s nothing happening, it’s boring” – boy year 4 class.

In the case of the first football scene, the majority of negative stickers were applied to the announcer’s dialogue. Questioning pupils about this scene suggested that they had not yet grasped the storyline and were confused as to what was going on at this point. In the case of the two frames leading up to the conversion of the football pitch into an ice rink, it was clear that children had not understood the action taking place. The dialogue and visual elements appear to have not clearly indicated that the Chemedian was about to turn the pitch into ice.

Although pretesting of the comic strip suggested that children would prefer dialogue to be presented in the vernacular (e.g. gonna) rather than grammatically correct English, it was clear from the application of stickers that a small minority of children found these words difficult to read. Words such as 'gonna' may be largely understood when spoken, but caused some difficulty when encountered in printed form for some readers.

Understanding the Science

Group discussion was used to assess whether children had understood the scientific concepts presented in the comic strip. These revolved around three key ‘tricks’ played by the Chemedian (changing a football into a balloon, changing a football pitch into an ice rink, replacing elastic with string). Children were able to apply appropriate vocabulary to describe the reasons why some materials work for a given purpose and others don’t.

Balloon versus Football comparisons included:

"A balloon is squashy and stretchy" - pupil in year 3/4 class

"In a proper ball it's all hard and you kick it and it goes further" - year 4/5 pupil

| Elastic versus string comparisons included:

"Elastic is tight and can hold them [shorts] up" -pupil year 3 class

"If you pull it and then let go it goes back to its shape" - year 4/5 pupil

| Ice versus grass comparisons included:

"Everyone slips" - year 4 pupil's response to the question "Why don't we play football on an ice rink?"

"You can't kick because you'll slip and fall over" -year 3/4 pupil

However, when probed to see whether they understood the nature of the changes made by the Chemedian, children appeared not to have grasped that her purpose was to change the properties of materials. Thus, when asked what the Chemedian might do in their classroom, answers consistently revolved around explosions and dramatic events and a significant amount of probing was needed to elicit answers relating to changes in the property of materials (e.g. turning chair legs to jelly).

Teachers' views of the comic strip as a classroom tool

Teachers all commented that the comic strip held children's attention and that the children concentrated well when reading and applying stickers. It was noted that boys in particular seemed to engage with the activity:

"Comic strips generally keep their attention, especially boys" - year 4 teacher

"Children used information to make sense of what they read. Most enjoyed reading the comic strip and labelled parts they liked" - year 4/5 teacher and science co-ordinator

"Children all started chuckling" - year 3/4 teacher, school with below average achievement

In addition, teachers noted that the combination of visual and text-based narrative helped students who were less inclined or less able to read.

"I thought it engaged the ones who were interested in the visuals to read" year 4/5 teacher

"The less able students were also able to engage in the task by looking at the pictures" - year 4 teacher.

In general, teachers felt that this approach could be adapted and applied to a school setting, perhaps as an introduction to a new unit of study or as a revision aid for older pupils.

Discussion

Fenwick (1998) argues for the use of comics in the classroom on the basis that comics are useful for reading comprehension, visual literacy and punctuation amongst other functions. It is clear from this project that children enjoyed reading “The Chemedian and the Crazy Football Match” and the results suggest that children understood the science presented in the comic. All teachers interviewed as part of this project indicated that they did not routinely use comic strips in the classroom and liked the opportunity to provide cross-curricular links offered by this approach. However, it was clear that the comic strip approach would not replace traditional hands-on science teaching which was also felt to be extremely important.

“These children don’t have many scientific experiences. I think they need more practical science experience” – year 3/4 teacher, underperforming school

Worthy, Moorman and Turner (1999) highlight the power of comics to catch children’s interest and suggest that this power could be harnessed by bringing comics into the classroom. The advantage of creating such bespoke materials is that they can be directly linked to schemes of study already in use in the classroom, thereby reinforcing material taught in more traditional ways.

Newton (2002) argues that stories can help children understand science concepts because they can be used to provide context to a problem or explanation. A story can also be used as a prompt for questions. This study strongly supports this argument. The comic strip is driven by a narrative that is delivered through both text and visual imagery. The narrative is one with which many children can easily relate – a football match. Added interest is provided by casting the two teams as unequally matched and until the Chemedian arrives and begins to play tricks on the ‘winning’ team, it looks like ‘Smasham United’ is guaranteed to win. Thus, the comic draws on a theme common in many commercial comic strips – that of helping an underdog to overcome adversity.

It was clear from the children's responses that they had understood the narrative (both visual and textual) of the comic strip and some sophisticated interpretations of the story and character emerged:

"She's going to let Wing City win - it's really good" - pupil, year 4 class

"She's not playing fair, but then the other team wasn't either" - pupil year 5/4 class

As can be seen from these excerpts, the children clearly understood that the Chemedian was purposefully trying to change the outcome of the match. Most of the children found this morally acceptable, justifying her actions by comparison with the actions of the Smasham United players. However, some children identified the character as primarily naughty, because she was interfering with the match.

"What she's doing tells me she's naughty" - pupil, year 3/4 class

"I don't like her. I think she's too naughty, and she spoils their game" - pupil, year 3/4 class

It was also clear that children were able to contextualise the science presented by relating the action depicted in the comic strip to their own everyday experience. Thus, the combination of visual and textual narrative appears to convey the scientific concepts in such a way that children relate them to the everyday world. For example, one child responded when asked why we don't make goal posts out of cardboard:

"If it rains, they go soggy and squashy" - pupil, year 3/4 class

While other pupils noted that we don't play football on an ice rink because:

"The goal keeper might slide into the goal and get hurt or score an own goal" - pupil, year 4 class

Strube (1990) notes that narrative is rarely employed in science teaching. It is clear from this study that narrative can be used to reinforce scientific principles and that children clearly related to and understood the specific scientific examples presented in this narrative context. However, it should be noted that in this study children did not extrapolate from this narrative to provide ideas about how the character would act in other situations (e.g. how she would use her powers to change materials). There are several possible reasons for this lack of generalisation. Firstly, children may not have understood the play on words (Chemedian and comedian). Secondly, children may not be sufficiently familiar with this particular character to make distinctions between her and a more general understanding of how comic strip characters behave. Finally, children may not have a sufficiently sophisticated concept of chemistry to confine their suggestions to actions which would be 'in character' for the Chemedian (that is actions which involve changes to the properties of materials). We attempted to address potential confusion about the name of the central character by introducing her at the start of the session. This was done by explaining that 'chemistry + comedy = Chemedian'. Further research is required to explore the reasons underlying the lack of generalisation of the Chemedian's actions, particularly in relation to the potential merging of the comic strip genre into a 'standard' character model as this would limit its utility in the classroom.

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The Chemedian clearly draws on a wider phenomenon in children's writing, that of the magical character. However, unlike many popular characters, such as Harry Potter, the Chemedian's magical properties are used to illustrate scientific principles. In this sense, the Chemedian in some senses bridges the fantasy and science fiction genres, by drawing on characterisation techniques associated with fantasy and placing them in a scientific context. In considering the positive reception of the comic strip, it should be remembered that children often respond positively to activities which are different from the usual classroom routine. All teachers involved in the project indicated that they did not use materials like these in class and so the novelty of the project may have contributed to its positive reception.

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42

43 **Figures**

44 Figure 1: Although more funny stickers were applied to the visual frame, a large number of stickers
45 were also applied to the text.
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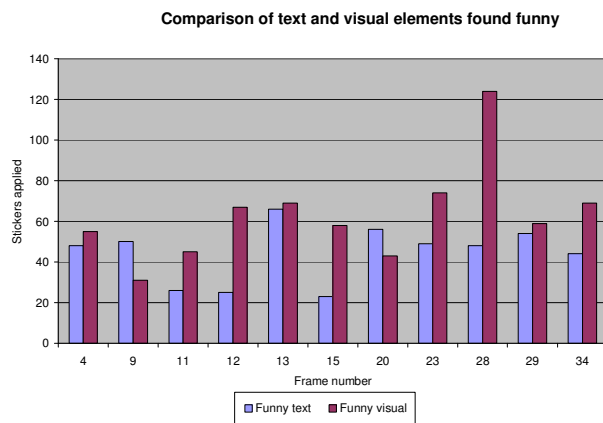


Table 1: Children's character preferences

Illustrator initials	DP	CS	DS
Character liked best	3	0	20
Character with best adventures	3	0	14

Table 2: Frames where the number of "funny" stickers applied exceeded the number of "negative" stickers by at least 50

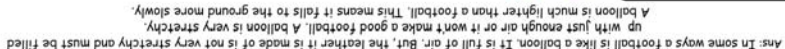
Frame and description of action	Difference between funny and don't like stickers applied to frame
Frame 4 - Explosion	77
Frame 9 - Chemdian on skateboard	58
Frame 11 - Filling balloon with baking soda	52
Frame 12 - Balloon blowing up and ball switch	69
Frame 13 - Striker kicking balloon	114
Frame 15 - Chemedian's goal	59
Frame 20 - Skating goal	59
Frame 23 - Spitting coach	93
Frame 28 - Shorts down, player falling	116
Frame 29 - Coach examining shorts	87
Frame 34 - Bent goal, celebrating players	74



First page of the comic strip. Provided courtesy of the Royal Society of Chemistry.
209x297mm (300 x 300 DPI)



Page 2 of the comic strip. Provided courtesy of the Royal Society of Chemistry.
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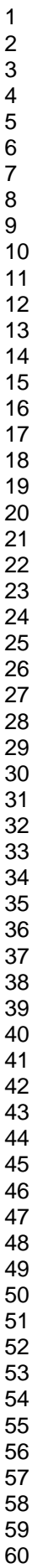


Page 3 of comic strip. Provided courtesy of the Royal Society of Chemistry.
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Ans: Ice is hard, smooth and slippery. The players' boots don't get a good grip on ice. On a grass pitch the cleats can dig into the mud, giving the players good grip. They can use this grip to help them run fast.

Page 4 of comic strip. Provided courtesy of the Royal Society of Chemistry.
209x297mm (300 x 300 DPI)



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Page 6 of the comic strip. Provided courtesy of the Royal Society of Chemistry.
209x297mm (300 x 300 DPI)

From: Colin Osborne [OsborneC@rsc.org]

Sent: 31 October 2006 10:40

To: Emma Weitkamp

Subject: RE: Chemedian artwork use

Emma

To confirm our phone conversation

Permission granted.

Look forward to a proposal in January.

Dr Colin Osborne CSci CChem FRSC,
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For chemistry resources look at Learnnet
<http://www.chemsoc.org/networks/learnnet>

www.rsc.org and www.chemsoc.org

Renew your RSC membership online at <http://www.rsc.org/members>

From: Emma Weitkamp [mailto:Emma.Weitkamp@uwe.ac.uk]

Sent: 26 October 2006 10:31

To: Colin Osborne

Subject: Chemedian artwork use

Colin,

I'm just following up my earlier email regarding permission to use part of the Chemedian comic strip in an academic publication. As I mentioned, I have had a paper accepted based on this project but the journal would like to include some or all of the comic strip to illustrate the project. I know that when we agreed the project, the Royal Society of Chemistry retained copyright. I would just like to know whether they would grant permission for the journal (International Journal of Science Education) to reproduce one or more pages from the comic strip (please advise as to what is acceptable) and whether this could be done in black and white or would need to be done in colour.

I also wondered if the Royal Society of Chemistry was interested in further developments of the Chemedian character.

I gather from phoning today that you are out of the office, but should be in tomorrow. I will try and ring tomorrow morning, though I am out on a research project and may not get a chance.

Best regards,

Emma

Emma Weitkamp, PhD
Senior Lecturer, Science Communication
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This email was independently scanned for viruses by McAfee anti-virus software and none were found

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