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Billions of blue blistering barnacles! What we can learn from comics about the visualization of complex ideas

Educational methods and innovations in engineering education

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Abstract—Science education is both a science and an art; getting the message across to groups of laymen requires a lot of thought. Some comics, such as the French Asterix, the American XKCD, or the Dutch Fokke & Sukke, have mastered the art of making people both laugh and think. Supporting learning with laughter could provide a powerful tool to enhance educational messages one is trying to get across, as multiple researches have shown that the use of humor helps students to e.g., remember material better. Furthermore, the image-based nature of comics greatly helps to visualize complex concepts. For instance, some comics use characterization and/or simplification to detach from reality, which is an interesting concept if you are treating heavy or complex subjects. Additionally, the use of stories rather than dry text helps to capture and retain the attention of the audience.

However, not every style is equally suited for every topic. The level of detail, color scheme, and drawing style radiate an atmosphere that can either make or break the message you are sending. Still, if used with care, comic-like illustrations and storytelling can greatly support any educational strategy. This paper highlights different visualization styles and choices, and what messages they subtly tell. Choices such as realistic versus caricaturistic, the level of detail, and the use of color are discussed. Furthermore, the effect of different styles of humor and some storytelling tricks are detailed.

Keywords—Science education, science communication, comics

I. INTRODUCTION

With great knowledge comes great responsibility; communicating scientific results and theories to students and laymen is one of the key tasks of a scientist. However, the general public becomes more and more critical to scientific theories as the public debate hardens [1], [2]. To break the cycle of distrust, creative solutions are required to effectively converse with student and laymen audiences.

The goal of science communication is to radiate a message to a target audience. In short, a typically complex or abstract message needs to be simplified and shared. Afterwards, the audience needs to take certain action, in education often to remember the information or to change their opinion on a certain matter. However, tuning a complex message to the desired reaction of the audience is an intricate process.

Comics are popular media that particularly excel in multi-layered storytelling. Many comics have, aside from amusement-related goals, a sub-goal of informing the reader [3]. For instance, the French adventure comic Asterix tells the story of a group of Gauls in constant conflict with the Roman conquerors in 50 B.C. [4], and, in the process, teaches a lot of history, ancient culture, and even reflections of modern culture [5]. The comic shows the perspectives of both Gauls and Romans (albeit not fifty-fifty), and therefore challenges the notion that all aspects of life in Roman-dominated territory were well-organized.

Another example is XKCD, a science-based webcomic, notably without a clear main character. This comic highlights, among others, the (ab)use of modern inventions, mathematics, and misinterpretations of science [6]. It introduces a plethora of fun facts in order to make a point and often highlights the dangers of sloppy science communication.

A final example is the one-panel comics of Fokke & Sukke, which tends to exaggerate (or misinterpret) the news [7], and by doing so inform the reader about recent events and challenge the opinion of the audience.

Some of the concepts behind comic-book related storytelling can be applied in science education and communication. This paper analyzes the storytelling strategies that are used in many comics, and how these can be implemented in science communication.

II. STORYTELLING TECHNIQUES

Presenting dry information to the public has often proven to be ineffective. Information presented in a purely auditory [1] or textual fashion [8] is generally remembered poorly. Furthermore, there is much evidence that suggests that most people only possess limited graph literacy and focus on context rather than on the data themselves [9].

Comics are based on stories, and storytelling is a strong strategy to influence the public. Research shows that stories help to make ideas meaningful to a broad audience and therefore make science more accessible [10]. Furthermore, ‘make-believe’ presentations of factual information were shown to enhance logical reasoning in test audiences more than ‘matter-of-fact’ presentations of the same information did [11]. Franker even states that “*Stories engage us and*

make it much easier to comprehend and remember concepts (think plots), facts (think events), and players (think characters)” [1]. Hence pouring information into a story greatly enhances its reception by the readers.

We can identify several linguistic and visual elements or tricks that are often used to strengthen the narrative in comics.

A. Information Pace

The density of the information appears to play an important role in how it is perceived and processed by the audience. Miller’s law suggests that humans generally can only store seven pieces of information in their short-term memory [12]. Comics limit the information density due to the limited space per frame that is available for text, which often automatically creates a pace that is comprehensible for most people.

B. Combined Visuals and Text

The information in comics is smeared out over both words and images. There is strong evidence that use of images combined with language helps people to remember more of the information presented [1], [8]. Schematized text has a similar effect, as presenting data in graphs or tables also increases how well information can be memorized [8].

The use of combined linguistics and visuals not only aids any audience in general, but it particularly helps to bridge language gaps. This enables comics to better cater e.g., non-native speakers than pure textual information would.

C. Visual Style Figures

There are many ways through which a visualization technique or style can shape the message that an image radiates. The style of an image can greatly set the tone of a picture. There are many design choices to be made regarding the style, but the most important ones are the attractiveness, the level of detail, and the level of realism.

Considering design in general, Norman poses that “*Attractive things make people feel good, which in turn makes them think more creatively*” [13]. The observations of Norman suggest that people work with a new device easier when its interface is visually appealing; the same is likely true for new pieces of information. Hence beauty can be used to present new information and to boost creative thinking.

Parallel to the enhanced creativity evoked by beauty, ‘ugly’ images are associated with pain, fear, disgust, and distress [14]. People tend to focus more when they are in an anxious mood [13], and deliberately unappealing images can be used to exasperate the reader. Think about the ‘bad guy’ in movies, who is rarely as handsome as the hero (and if he is, he often has a change of heart as a part of the plot). There are even authors who use unappealing drawings to create a provocative art style, which is well-suited to support crude humor. For example, see the Kabouter Wesley comics by Jonas Geirnaert [15].

Colors can further influence the perception of the image, and can have an impact on the emotions, cognition, and behavior it provokes. The meaning of a color is often context-specific, but chromatics studies have shown that certain colors are sometimes associated with abstract concepts such as calmness, peace or danger [16].

Overall, beauty is in the eye of the beholder. Still, beauty is often perceived at situations or objects that evoke positive reactions, such as symmetrical objects or patterns, smiling faces, smooth objects, and bright hues. Negative emotions are associated with darkness, sharp or misshapen objects, and rotting [13]. In conclusion, using bright colors, regular patterns, smooth shapes, and symmetry are preferred when you aim to create an aesthetically pleasing art style. Irregular, crude, and dark shapes evoke a reverse effect.

Detailed images require more time to be read; the level of detail can therefore be adapted to the complexity of the message. Low-detailed visuals are more than sufficient to support simple or known data without risking to distract from the actual point you are trying to make [1]. The reader can get bored, however, if the entire comic is slow and not challenging. Overall, longer stories could benefit from more detailed images to keep the reader engaged.

Lastly, the level of realism influences the message a comic radiates. Caricatures can convey more extreme messages. For instance, consider Asterix knocking out a Roman, which is a joke often used in the comics. It is only funny because the visualization style is nowhere realistic; a true-to-nature depiction of knocking a character unconscious would show agonizing wounds and would result in traumatic brain injury or even death [17]. This disassociation can be explained using Trope and Liberman’s construal level theory [18], which suggests that abstract events (e.g., drawings) feel psychological distant.

In summary, the psychological distance determines the humor that can be conveyed [19]. Tougher jokes can be made about situations that are geographically, socially, temporally, or hypothetically distant (unlikely to happen) from the reader, and the same accounts for characters that are caricatures.

Contrary to caricatures, realism brings the situation close to the reader, and often radiates the message ‘this can happen to you.’ So as a rule of thumb, realism supports drama better than humor. Hence, despite that realistic images are often perceived as attractive and recognizable, realism should be used with great care.

D. Composition and Background

On the level of a single image, the composition can be used to focus the attention of the reader. The golden ratio is classically deemed an aesthetically pleasing division of a line [20], and artists therefore often place objects or characters they want to draw attention to at that position. Similar composition strategies involve arranging things in a triangle shape or at the diagonals of a picture.



Fig. 1. A photocomic about communication effectiveness by Ype Driessen and Ionica Smeets [31]. The comic has been translated and shortened for this paper; the original comic was longer, further strengthening the punchline. Also note the little easter egg in the first image, where Ype is reading a comic book that he wrote by himself. Edited with permission of the authors.

Furthermore, a sense of chronology can be generated by placing important objects from left to right (the reading order in a Western context) or from front to back, which creates a story within a single image. Lastly, detailed versus undetailed or even blurred pieces of an image can further guide the reader in focusing on the most important information presented.

III. HUMOR

The use of humor has advantages regarding memory and motivation. Many studies have shown that humorous notes are remembered better [21], [22]. Some studies even suggest that people are more willing to share funny anecdotes [23], which makes the information travel further. Additionally, humor provides a respite from repetitive tasks and allows people to persist longer when performing tedious operations [24]. Hence humor can assist educational material through supporting the memory and the motivation of students.

While humor has many advantages, there are also a few points of concern. First of all, the humor should be directed well. Commenting on a minority group you are not a part of, for instance, can irritate the reader and, as a result,

discredit the rest of your story. Furthermore, the amount of humor needs to be dosed well. A hilarious comic might miss the educational goal because the reader no longer takes the comic seriously, and with it the information the comic contains. Another disadvantage of a message that is too funny, is that it is known to distract attention from the main message [25]. This is, by communication practitioners, often referred to as the vampire effect [26].

Humor in comics can take verbal or visual form. Verbal humor often comes in the form of wordplay, analogies, metaphors or puns. Contradictions or exaggerations between the image and the text can be a source of humor as well [27]. Similarly, gestures, expressions, and artefacts in comics are often exaggerated as a form of visual humor. Furthermore, some authors hide little jokes in the background. Think for instance about a character carrying a large pile of money with coins and banknotes falling off here and there. All in all, wordplay and visual exaggeration make up most of the comic humor.

IV. EXAMPLES

In this section, some examples of comics with an educational subgoal are presented and briefly analyzed.

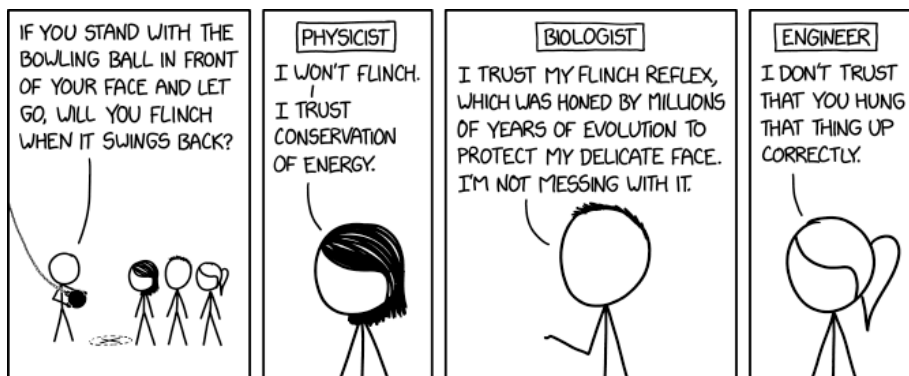


Fig. 2. A drawn comic by Randall Munroe about the flinching reflex [34].

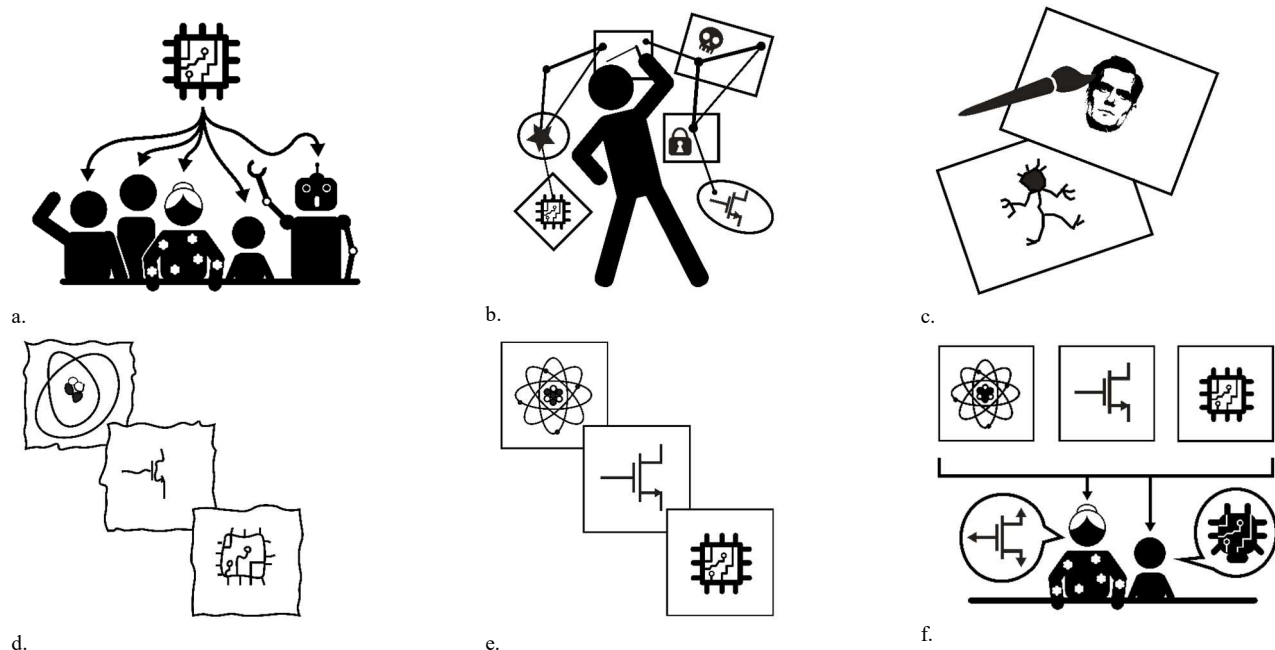


Fig. 2. An icon-style comic of the instructions for creating an educational comic as generated by the authors of this paper. a. Determine the learning goals and your target audience. b. Create a narrative that fits the assumed knowledge level of your audience and assess which information you need to include. c. Choose a visualization style while keeping the tone and learning goals of your comic in mind. d. Create a storyboard. e. Generate the actual comic. f. Present you comic to a test audience/colleague for feedback. Check whether they understand the information that is presented. Keep revising until your goals are reached and the comic is finally ready to conquer the world.

Because there are many excellent examples of this type of comic, we focus on styles that can be reproduced by an untrained visual artist with relative ease.

A. Ype and Ionica

The story of Ype and Ionica comics by artist Ype Driessen generally builds up by first presenting the information the authors want to teach you and ends with a humoristic punchline which helps the reader to remember said info, see Fig. 1. The style – a photocomic – is unusual as realism often supports drama better than comedy, but the exaggerated facial expressions and gestures and bright colors give the comic a humoristic touch nonetheless.

B. XKCD

The comics of artist Randall Munroe, especially XKCD, are often packed with information and fun facts which help to build up the punchline, such as the example shown in Fig. 2. The minimalistic art style and lack of facial expressions radiate a simpleness that is not matched by the eloquent language used in the comic. This form of self-mockery is used to alleviate the serious topics that are often present in the comic, such as the darker undertone of

warnings about science abuse and the dangers of miscommunication between groups of people.

C. Icons

Icons often show only little more than the basics of a topic, see Fig. 3. The lack of detail helps the reader to focus on the essentials. Leaving out secondary information also invites the audience to fill in details by themselves. For these reasons, icons detach from reality and provide a nice focus on the essentials.

Icons are very suitable to support or summarize complex, detailed information; icons are often used on websites because the elegant style makes them fitting for many occasions. The distance from reality can also be used to create comics with a very sarcastic undertone as is done in, for instance, the Unbelievably Bad webcomic by James Breakwell [28]. Hence icons can certainly be used in a humoristic way.

Many icons are relatively easy to create from a few squares and circles. Furthermore, there are many free image

databases that can help you get started on your comic or presentation.

V. HOW TO WRITE AN EDUCATIONAL COMIC

By combining the aforementioned observations, one can identify the following phases in the creation of an educational comic. See Fig. 3 for a visual overview.

A. Preparation

Determine the learning goals and the take-home messages of your comic. Additionally, identify the target audience [29]. Estimate the background knowledge of the perceived audience to determine what information should be provided for the comic to be understood.

B. Create a Narrative

The creative part of the process starts here. Consider the tone of your message: is it neutral or colored? In the case you would like to show one or multiple different opinions, you might want to consider introducing some characters. If it is neutral like e.g., explaining a mathematical concept, an all-knowing narrator can help you out, as is done in some of the more informative PhD Comics by Jorge Cham [30]. Also consider the background situation of your comic. Sketches can greatly help you to progress your ideas.

C. Choose a Visualization Style

Regard the timbre of your message, the length of the story, and the complexity of the information. Consider the learning goals of your comic. Use an appealing style to get your audience in a good and creative mood [13], or use a despicable style to provoke your audience. You could decide to break style now and then, which puts a specific piece of information in the spotlights.

Furthermore, a serious atmosphere should be set for a serious message. As a rule of thumb, more realistic images and darker tones generate a more serious atmosphere than surreal, bright-colored pictures. But be creative, as many exceptions to these rules exist!

For longer stories, a more detailed and consistent style could help retain the engagement of the reader. Furthermore, the use of symbols can often help to visualize abstract concepts. Think about notions such as love and death, which are very complex concepts to explain, but that can be expressed with ease through the use of simple symbols.

If you have little to none experience with drawing, there are many alternatives art forms that you can use for your comic. We already mentioned the option of using photos [31], creating only minimalistic [6], or crude drawings [15], or going for easy-to-produce icons. Furthermore, free comic-oriented databases exist that enable you to generate a story with generic images [32]. And if you feel you could never achieve the greatness of famous comic artists, just read an early Spirou or Willy & Wanda to convince yourself that it simply takes some time to develop and become accustomed to your own style.

D. Create a Storyboard

With the message, narrative, and visualization style in mind, you can create a storyboard. Roughly make an outline for the story, and work out which information is revealed when and where. Set up first drafts of the text. In general, avoid long and wordy phrases, and preferably visualize concepts as much as possible. Use humor to keep the story digestible and to underline key aspects of your story, but use it in moderation. Humor should be well-timed and dosed, especially in respect to the information that is given. In the case of engineering problems, sarcasm, dark humor, and exaggerations are generally perceived well.

E. Draw/Generate the Comic

Create the actual comic. Even at this stage, inserting minor changes compared to the storyboard is very common.

F. Test and Revise

A test audience can help to determine whether your story is clear and whether the information you present is understood. Keep revising until you are happy and the learning goals are reached.

VI. CONCLUSIONS

Comics can help connecting with society, or with an audience. The bar to read a comic is much lower than the barrier to read a source predominantly consisting of text. And, as stated previously in this paper, comics attract attention and have a positive influence on memory and motivation due to the strong combination of text, images and humor. Through the visual side of storytelling, comics can even bridge language gaps.

Hence, the possible applications of comics in education are endless. Interchanging information with short comics, such as one-panel jokes or memes, can help to keep the student's attention. Also, they can be used to underline statements and conclusions. By using comics as snarky sidenotes, you can invite an audience into thinking critically. Comic-supported visual summaries can help to highlight the important data and arguments of an otherwise complex story.

As a closing remark, Stigler's law of eponymy states that scientific laws and inventions are never named after their original discoverer. Far more often, the person who communicates the idea effectively receives the credits. In a way, Stigler's law beautifully captures the importance of science communication. Any idea, however brilliant, remains just a thought until you manage to reach other people. Or as Smeets puts it: "*Connecting with society is an essential but underrated part of being a scientist*" [33]. The same goes for effective education.

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