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Information Comics

Risks and Pitfalls

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Can educational comics ameliorate the public understanding of a science that may transform our lives, but whose basics only the experts understand? Synthetic biology (Nature 2004) is a new science in this sense. The concept *synthetic biology* sounded like science fiction just a few years ago. Synthetic biology not only manipulates genetic information, as does the well-known field of biotechnology; it also claims even to create new life forms by combining molecular biology, chemistry, and engineering techniques. Synthetic biology is therefore faced with a challenge to convince the public not only of its global benefits, but also of its harmlessness.

Searching for new ways to present the new science in Switzerland, the Swiss Academy of Sciences, an institution committed to dialogue between science and society, became aware of a U.S. comic about synthetic biology which had received a lot of attention and acclaim from experts in the field: *Adventures in Synthetic Biology* (Endy 2005). In the U.S., scientific comics have been the subject of experimental research for some time (Gerstner 2003), so the decision to try this new mode of communication is obvious.¹ But the adaptation of this comic that had received excellent reviews in the U.S. resulted in a debacle in Switzerland.² It was this debacle that prompted us to investigate the risks and pitfalls associated with knowledge communicated through educational comics.

The Problem

What was the intention of creating, publishing and adapting a comic about synthetic biology and how was its public reception in Switzerland? Similarly to the Swiss Academy of Sciences, the MIT Synthetic Biology Working Group, namely the group of synthetic biologist Drew Endy,³ invested a lot of time and energy to find better methods to communicate information about synthetic biology in an easily understandable way. These efforts mainly targeted students, but anyone who might be interested should be given access to this topic and to the new methods by which the concept and the potential of synthetic biology could be assessed and outlined. It soon turned out to be a difficult undertaking, to introduce college students to the concept of "common signal carriers," for example. To better convey the idea, the MIT scientists visualized their ideas through abstract graphics, such as this:

As they were discussing the problems of this visualization, a new idea was born: that synthetic biology and its contents could only be conveyed in a narrative form that also uses visual representations, e.g., in a comic. Drew Endy, who was convinced of the potential of comics for knowledge transfer, made a first draft of the comic. Drew Endy and Isadora Deese wrote it. Comic artist Chuck Wadey was asked to do the drawings. He suggested adding an introductory chapter to familiarize both students and laypeople with this new science.⁴

The result of this project, *Adventures in Synthetic Biology*, is a hand-drawn educational comic in the style of a conventional American adventure comic, with use of onomatopoeia, speech bubbles, and many other typical characteristics of comics. Despite the fact that its main task is knowledge transfer, it also contains fictional elements. The comic tells the story of a curious young guy, Dude, a novice in the domain of synthetic biology, whose features resemble those of Drew Endy himself. Under the critical eye of a mother-like mentor he is experimenting with the techniques of synthetic biology, while the mentor explains (to him and to the reader) the scientific background, the principle of genetic inverters, how to correctly connect modules, how to enable DNA programming. After a failed experiment with exploding objects and after being equipped with new systematic methods and the basics of engineering technology, Dude shows his genius by creating some kind of genetic balloons, only the first step for future genetic engineers building new “stuff” like “engineered insulin-producing cells.”

The story and its characters are full of vivid exaggerations: bacteria as large as pets, humongous injections, a journey to the core of a cell, a boy in the role of an ingenious and brave scientist who finds the solution that will lay the foundation for a new science. The idea was that students in the field of synthetic biology could now learn about this concept by reading an educational comic, an idea that attracted attention quickly. The comic was even introduced in a 2005 edition of the journal *Nature*, No. 238, and got front page coverage (Endy 2005). Regardless of its original target public (American biology students), the Swiss Academy of Sciences perceived the comic as an ideal medium to introduce synthetic biology in Switzerland.

The decision makers never considered modifying parts or even whole chapters of it—perhaps due to its success in the U.S. In addition, copyrights might have prohibited modifications anyway. The comic was translated from U.S. English into French and German (the two most widely used official languages in Switzerland) and presented at a media event which was part of a synthetic biology conference at the Swiss Federal Institute of Technology, Zurich. However, the comic’s U.S. success could not be repeated in Switzerland. The media reacted with skepticism or even harsh criticism to this project launched by the Swiss Academy

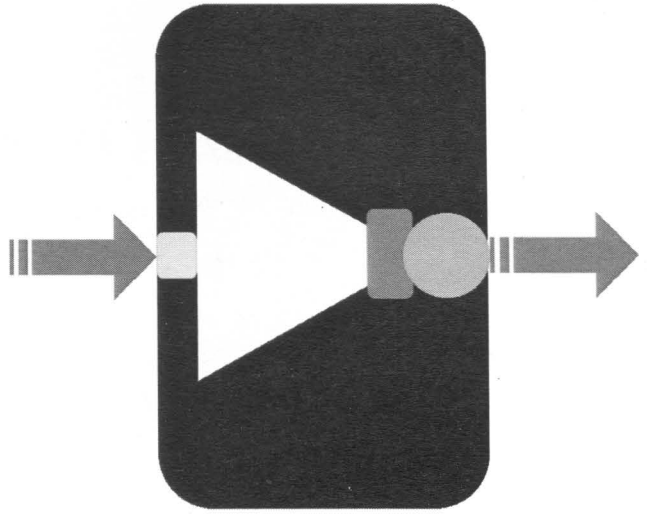


Figure 1. Abstract depiction of genetic inverter, http://openwetware.org/wiki/Adventure_Background

Gen-Forscher werben mit **Monstern**



VON RETO KOHLER

BERN. Absurd! Ausgerechnet mit grünen Monstern wollen uns Forscher für Gentechnologie begeistern.

Wenn seriöse Wissenschaftler lustig sein wollen, kommt das selten gut heraus. So ist das auch bei einem bizarren Gentech-Comic, den uns die Schwei-

zerische Akademie für Wissenschaft (Scnat) nun beschert.

Das 11-seitige Heftchen soll uns die moderne Gentechnologie schmackhaft machen. «Der Comic richtet sich an eine breite Öffentlichkeit», sagt Stefan Nussbaum von Scnat. «Wir wollen damit eine Diskussion über das Thema anregen.»

Man entschied sich für eine heitere Variante. Und das ging in die Hose.

Im Comic bastelt ein kleiner Junge ein genetisch verändertes Wesen. Beim Tierchen handelt es sich um ein grünes Ding, das aussieht wie eine Mischung zwischen Barbapapa und Darmparasit.

Mit einer grossen Spritze injiziert der Junge, der eine Taucherbrille trägt, fremdes Erbgut in das Tierchen. Das Experiment geht schief. Das kleine grüne Schleimding bläht sich auf,

verwandelt sich in ein riesiges Monster – und platzt. Die Fetzen des Monsters verursachen im Labor eine extreme Sauerei.

Besonders verwirrend: Die Geschichte des kleinen Jungen macht auch bei mehrmaliger Lektüre keinen Sinn.

«Dieser Comic lässt mich völlig ratlos», sagt

Yves Zenger, Sprecher von Greenpeace.

Er kann darin keinen brauchbaren Diskussionsbeitrag erkennen. Im Gegenteil: «So macht man sich über die berechtigten Ängste der Leute vor der Gentechnik lustig.»

Figure 2. “Researchers promote gene technology with monsters,”—an example of a media critique of the comic. “Blick,” June 13, 2007.

of Sciences (Hofmann 2008). *WOZ*, a weekly newspaper for a young, progressive audience, criticized the naiveté with which the comic approached artificial life, and how it downplayed the dangers inherent in biotechnology. Even the traditional newspaper *Der Bund* dedicated an entire article to it, dismissing as a failure the academy’s endeavor to stimulate discussion of a “sensitive topic” and to visualize complex subject matter in a comic (Imhasly 2007). The article states, “We inevitably feel discomfort when we see a boy inject a humongous syringe into a slimy bacterium that is squeaking in fear and does not stop growing until it finally bursts.”

These reviews of the academy’s endeavor to promote synthetic biology and to use the comic for this purpose were surpassed by an article about it in the tabloid *Blick*.⁵ Above an extract of the comic, we can see the large header in bold letters: “Researchers promote gene technology with monsters.” The article calls it a “bizarre gene technology comic” and a “serious researchers’ weird attempt to be ‘funny.’” The attempt to interest the wider public in gene technology went down the drain. According to the paper, quite the opposite was happening: the comic ridiculed people’s fears. “Despite rereading the comic several times, it does not make sense,” a Greenpeace spokesman is cited saying: it may only leave the reader perplexed.

Faced with such harsh public criticism, the Swiss Academy of Sciences decided to suspend the project and withdrew its decision to publish the comic for young people, the intended target population. A research group (the authors of this article) was commissioned

to investigate the perception of the comic and, in their results, try to identify potential communication pitfalls. Did the target population, young people, perceive the comic equally negatively? Considering the well-known arguments used against biotechnology, why did the comic evoke such harsh criticism of science, scientists' responsibilities, and the economization of science? What role did the medium of educational comics play?

Some Theoretical Reflections on the Information Comic

But first: What is an educational comic and what are the crucial points of this media form? An educational or information comic can be seen as a form of persuasive communication, which uses the cultural form of the comic as its medium. The comic itself, following the famous definition of Will Eisner (Eisner 2008), is a kind of "sequential art": it uses pictures and textual elements, mixing them together into a storyline. Based on this definition, Scott McCloud proposes, in his oeuvre "Understanding comics: the invisible art," an extended definition of comic. For him, a comic consists of "juxtaposed pictorial and other images in deliberate sequence, intended to convey information and/or to produce an aesthetic response in the viewer" (McCloud 1993, 9). In this definition, McCloud integrates the informational aspect of the comic, and his historical investigation of sequential images shows the long tradition of using sequential pictures for knowledge transfer, going back even to the hieroglyphs of Egypt. This extension of the concept of the comic is important for our research, showing that there is a long tradition of connecting pictorial storytelling with information transfer. However, this long history may hide the historical foundation of the reception of the picture sequence itself, or in other words: this definition perhaps leaves out the fact that the way of reading and seeing images and text is not constant over the decades, nor among different social milieus.⁶ Eisner points out that consequently, the comic superimposes "the regimens of art (e.g., perspective, symmetry, line) and the regimens of literature (e.g., grammar, plot, syntax)." As a consequence, the reader is "thus required to exercise both visual and verbal interpretative skills." (Eisner 2008, 2).

Following Eisner's insight, we are falling into a paradox: it seems the reception of the comic requires even more skills than the reception of a more homogenous medium like literature and art. Why are comics then usable to communicate knowledge? A closer look at the logic of the semiotic function of visual narratives like comics and graphic novels shows that they hold possibilities for communication that are unique, exactly because they combine the regimens of art and literature. Pictures, generating a holistic "presence" of something where a word-for-word description would be very extensive, represent a form of "thinking" that is different from one that language can communicate. Susanne K. Langer calls them presentational forms, in the sense that they create a meaningful presence or imaging of something. But pictures as presentational forms have their own logic: nobody can translate one picture (a Van Gogh) into another (a Picasso). A picture shows something, but what is showing lacks a clear definition, because the potential meaningful elements of pictures are genuinely polysemous. In contrast, the domain of words, the discursive forms, are explication, argumentation, translation, and the analytical, as Susanne K. Langer explains (Langer 1942). One can translate words into words of another language. One can make precise definition with verbal syntax.

But these regimens of presentational and discursive forms are often not isolated. Moreover, the combination of pictorial elements and words generates new possibilities that aren't just additive; they can explain themselves reciprocally. It is Roland Barthes who has discussed

the Comic as a specific form of a combination of words and images in this sense (Barthes 1977). If text is combined with pictures into a new form, the text can have two different functions: *anchorage* and *relay*. Anchorage means, that the text guides the reader through the picture, elucidating its meaning. Texts may have a supportive function to deliver clearly identifiable messages mediated by pictures. The text prevents the floating chain signified that an image contains from getting out of control for the reader, helping him to choose the correct level of perception. This combination of picture and anchor enables a form where text and image complement each other; even if the perceiver lacks skills in pictorial or textual interpreting of the message.⁷

The other function of text is relaying the images. The picture as a presentational form is static, as Langer wrote, while discursive forms are dynamic, and they tell a story in time, leading the eye through chains of signifiers. So text can combine fragments of presentational forms into a greater synthetic form, a new syntagm, a new semiotic unity. Where description by words is enormously costly, the pictures, as presentational forms, may bear a wide range of information efficiently, while the text fits the isolated pictures to the greater story. Especially in comics, Barthes tells us, "the costly message and the discursive message are made to coincide so that the hurried reader may be spared the boredom of verbal 'descriptions,' which are entrusted to the image, that is to say to a less 'laborious' system."

But for whom is this kind of reading valid? A combination of explicitly designed verbal and iconic signs can never cover all the possible meanings of a picture and its elements. There is always a "the rest" of the possible significances that undermines a semiotic system intending the integration of text and images. The connotation is always wider than intended. The example of the comic *Synthetic Biology* shows how the possible connotations that this educational comic evokes are quickly integrated in the political field of "battles" that accompanies the rise of a new biological science (Hall 1996): the question of manipulating and economizing life itself, lack of trust in the power of science, etc.: discourses that are "waiting" to interpret the surplus of meaning in a picture-text system as that presented in the comic "adventures in synthetic biology."⁸

However, according to Barthes, each dimension of symbolic signifying of an image (denotative pictorial elements, connotation of style, literal meaning of integrated words) is an object of interpretation that varies with the number varies depending on each specific act of reading and each different reader. In other words: balancing a productive combination of text and images in a pictorial storyline is difficult insofar as the kind of reading and combining them may vary not only between different groups of persons, but also in the different reading acts of one person, depending on which element of knowledge he is willing to activate, since a plurality and a co-existence of lexicons, or knowledge forms, coexists in one and the same person. (Or in other words, the "language of the image is not merely the totality of utterances emitted (...), it is also the totality of utterances received" (Barthes 1977, 47). But which instance determines what is received? It is not the symbolic form of the pictures and texts (the comic) itself. Receiving and interpreting a message generated by symbolic forms is also a question of the recipient, the individual combination and processing of symbolic forms and their meaning. But this "variation in reading," the activation of a lexicon, is never "anarchic": "it depends on the different kinds of knowledge — practical, national, cultural, aesthetic — invested in the image," therefore a variation that can even be "brought into a typology," as Barthes believed (Barthes 1977, 46).

With this horizon in mind, the question whether a comic is a "good" media for knowledge transfer can never be answered by discussing the medium of the comic itself. Moreover,

the question of which forms of reading and seeing, which skills are affected and which lexicons are activated, when an educational comic is read by different individuals, leads to the pitfalls that gave rise to the public critique of the concrete comic *Synthetic Biology*, as our thesis had in mind.

Researching Reception: Some Reflections on the Method

However, to our knowledge, perception research has not yet provided any instruments to measure perception of educational comics that would allow for a comparison of the comic in question with comparable media. Following our theoretical reflection, we first wanted to understand and explore the processes of reception of the educational comic. Consequently, we focused on the active individual who processes the reading act as a kind of “information” or semiotic processing on the basis of his knowledge and interests.¹⁰ In this sense, we were interested in differences in reading and interpreting, for the purpose of observing how reception or “information processing” varies on the basis of the same media form, to see what communicative forces of the form itself (the comic) can be identified. Empirically, we analyzed the reception of the educational comic using a qualitative inductive approach based mainly on *Grounded Theory* (Strauss and Corbin 1997). To gather data about the reception of the comic, we used focus groups, a traditional method used in communication and social science research (Bloor et al. 2001; Schäffer 2005). Focus groups seemed to be an ideal method because people tend to express criticism or a lack of understanding more openly if they see that others share their perceptions and attitudes. In addition, it can prevent participants from feeling as if they are being made to take an exam, such as in a one-to-one interview. The group dialogue promotes mutual inspiration to contribute to the discussion spontaneously and openly and invites reactions (Lamnek 2005).

The general method of focus groups first had to be adjusted to fit our research questions. The selection process when creating focus groups should generate the largest possible amount of assessments and perception patterns, rather than an imaginary average public. For this reason, we decided to work with four focus groups, each different in terms of relevant aspects/characteristic features of the educational comic, which would allow us to identify specific pitfalls and obstacles. In our design, we distinguished between participants with different competences and affinities: first, young people with an affinity to either the natural sciences or arts/graphics; second, experts in these two areas. This division allowed us a direct observation of the target population, while the expert groups were expected to articulate potential pitfalls and obstacles with precision, based on their prior knowledge. Consequently, our research design consisted of a matrix which distinguished between experts / target population and visual arts/graphics and natural sciences.

Qualitative Research Design: Focus Groups

	<i>Natural Sciences</i>	<i>Visual Arts/Graphics</i>
Target population: adolescents between 16 and 18 years	High school students — biology/ chemistry	High school students — visual arts
Experts	Biologists, engineers	Graphic artists, advertisers

To avoid the bias of national visual culture and national discourses about science, we decided to expand the design of our comparison groups, all of them from Switzerland (CH), by adding a focus group in the U.S., the origin culture of the comic. A collaboration with

the Monterey Institute of International Studies in California enabled us to have eight U.S. students from different academic tracks discuss the original American English version of the educational comic.

Each focus group had between six and nine participants. The number of participants should ideally be between five and twelve, as shown in previous research. A focus group should not be too small (minimum of five), so that a variety of opinions can be gathered; and it should not be too large either (maximum of twelve), so that all group members stay motivated to actively engage in the discussion (see Lamnek 2005). Focus groups are facilitated by a moderator. The moderator raises key questions from a prepared outline so the statements of the different focus groups can be compared. At the same time, the moderator should try to keep the conversation flowing so that key themes can emerge. Towards the end of the discussion, there is an opportunity to ask specific questions that may have remained unanswered. In our research, the discussions were videotaped and transcribed. Each discussion lasted between 55 and 90 minutes. All participant names used in the essay are pseudonyms.

First Results and a Research Strategy to Investigate the Material

The following example will show how difficult it is for the producers of a comic to predict and assess the pitfalls of the medium without communicating with the target public. The images have, as postulated by Barthes, a series of floating elements whose significance is hardly foreseeable. To exemplify this phenomenon and its meaning for educational comics, we will explore a tiny detail of *Adventures of Synthetic Biology*: the glasses of our young researcher's motherly friend and mentor. They are mirrored, which prevents us from seeing her eyes.

In addition, the glasses do not have temples, as if they were implanted in her face. Surprisingly, this minor detail was noticed by all focus groups even though it has no content value, and caused confusion, as illustrated by the following comments from the focus group in the U.S.:

And then her eyes. I didn't even notice it. But first I thought they were glasses but they... (Amy, graduate student, U.S.).

They're glasses (Jennifer, graduate student, U.S.).

No, they're not. There's no connection to her ears (Amy, graduate student, U.S.).

And she has some kind of cotton pads or something else on her eyes. I don't know what it is. And I keep asking myself: What role does it play in the story? (Wanda, graphic artist, CH)

It's totally strange that this woman should only have



Figure 3. A minor detail only? The mirrorshades. From Endy et al. 2005, 12.

two white [glass plates], a kind of glasses. Without these, she'd look much nicer (Elizabeth, high school student visual art/graphics, CH).

These glasses are really awful (Selena, high school student visual art/graphics, CH).

This confusion about the glasses, i.e., the inability to interpret their shape, led to rejection, even aversion towards the character (and her creator), as illustrated by the following snippets from a conversation among biologists/engineers:

Let's take the woman's glasses. Why can't you look her in the eyes, it's so ... (Betty, biologist, CH).

She herself is synthetic, almost like a robot (Christina, biologist, CH).

A graphic artist says:

That really also bothered me very much: You can never see her eyes. It totally confused me. It's so anonymous (Hannah, graphic artist, CH).

The high school students' reactions are similar:

It seems a bit negative, a bit evil. You don't see the woman's eyes. Yes, she seems a little mean (Selena, high school student visual art/graphics, CH).

What makes her seem so unfriendly? (moderator); Reply: The glasses (Lewis, high school student natural sciences, CH).

And most of all, the glasses she's wearing, she's so stupid (Peter, high school student natural sciences, CH).

Based on these statements, it is evident that this alienation also reflects on the reader's willingness to allow the mental processing of the comic's message. But then again, these statements cannot be generalized: the U.S. group, which was more open toward the medium of comics, expressed their confusion about the glasses, but they did not express negative feelings toward the researcher's character. Even the smallest details, which may go unnoticed by most, may have hidden meanings for readers. So, is it impossible to investigate the reception of the comic, because its floating signifiers will be processed completely by heterogeneous audiences, as they form the public of today?

This evidence we see as a result; nevertheless, we tried to search for some regularities, that might help to identify the pitfalls of an educational comic, without saying that we are able to create a guide to a well-performing comic. For a further analysis of the material we followed the methodological principles proposed by *Grounded Theory*. They consist of identifying the recurring arguments, patterns of statements, experiences, and evaluations recorded in the focus group conversations, which we tried to distil by concentrated discussion in our research group. This process of open coding is followed by a phase of "axial coding" for an aggregation of core themes to establish global categories that would facilitate interpretation. Thence the name of the method: the purpose of grounded theory is to extract general insights "grounded" in the collected data. Through this process, new dimensions and relations emerge that cannot be perceived at first glance.

The Cultural Background of Comic Reception and Further Questions

One core dimension shows, not very surprisingly, the significance of cultural background for reception and information processing, the different knowledge and lexicons that are invested to read the comic as a whole form. The focus group in the U.S. had a much

more positive attitude towards comics than the Swiss focus groups: As a matter of fact, they even consider comics an integrated part of their (visual) culture.

It's a format that we'll recognize, at least here in America, we recognize the format, we recognize the genre... I believe they are an integrated part of the American society, they are part of our culture (Sheila, graduate student, U.S.).

An American student who immigrated to the U.S. at the age of eleven explained that she had her own experience of this visual culture: she had not internalized the medium and language of comics to the extent that other Americans had.

I never grew up with comics until I came to the U.S. and that's when I was introduced to it. But I never got into it because I felt there was a gap between my cultural knowledge and the knowledge here. There would be jokes, and I would think, "Wait, that's funny? I don't get it." That was a demotivating factor for me. So I just kind of never got into comics (Mary, graduate student, U.S.).

Consequently, much more skepticism was felt among the Swiss focus groups. The following were typical statements:

I like comics ... it's a good way to explain complex topics. But I think this comic here is a bad example (Betty, biologist, CH).

I think they have chosen the right medium but maybe not the right kind of language (Rose, advertiser, CH).

I feel that knowledge cannot be transferred through comics. Comics are for fun, leisure, and fiction (Peter, high school student natural sciences, CH).

However, the Swiss participants' attitude was not generally negative towards comics. Consequently, the evidence of a cultural difference leads to further questions: what is exactly the reason for this skepticism towards this *educational* comic? What are its dimensions and what causes it? The above statements merely show that there must be barriers somewhere that prevented knowledge transfer and caused the participants to refuse active engagement with the material.

Visual, Narrative and Knowledge Dimension of the Comic

We searched for further categories and dimensions that determined perception and assessment of this comic. After examining the data, we believe we can distinguish aspects of the perception of this educational comic which are common to all the groups. For us, three main dimensions of messages were identifiable whenever group members discussed acceptance of the comic and its perceived quality. It also became evident that the interaction among the three dimensions constituted a crucial momentum, which led the participants to reject this comic as a medium for knowledge transfer.

The first category of impressions was based on the *visual aspects* of the comic: Here, we refer to the images that were evaluated and questioned, and which either attracted the readers or put them off; this dimension corresponds in some ways to the paradigmatic dimensions of images (style, effect, colors) (Barthes 1977: 41). The comic also tells a story; it is a narration with a cast of characters, and with a specific dramatization. We call this second dimension the *narrative dimension*; it corresponds to what Barthes calls syntagmatic component pictures, of relaying pictures and texts, integrating the reader into a story he can "live with." Finally, educational comics have an independent *dimension of knowledge*

transfer: The readers feels themselves challenged to identify what kind of knowledge is provided, what exactly they are supposed to learn.

The readers did not process the three dimensions in an isolated manner. And it is also the perceived relation between them that determined how the readers handled the comic as a whole, influencing the intention to learn from it, as our research showed. Nevertheless, they form independent dimensions with specific properties and specific messages perceived by the readers, as the following examples should illustrate.

As aspects of the *visual dimension* we recognized that the drawing style, the elaboration of details, and the colors that create different atmospheres are core themes which can be seen. These clearly emerged when the appeal of the images was discussed.

When I started to read, then I got into it because it's pretty with these pictures (Mary, graduate student, U.S.).

Everybody here when you asked what we liked about the comic said, "Oh, pretty colors, pretty images." I don't think that they're distracting because we still all read it (Sheila, Jennifer, graduate students, U.S.).

I totally dislike the style. It doesn't appeal to me at all. For example the fingers, the hands, the way they're drawn (Michael, graphic artist, CH).

Everything looks so menacing. The woman on page 8 against the explosive background. On page 9 the woman who just enters the room, green like a nuclear reactor (José, engineer, CH).

The *narrative dimension*, i.e., the story, is less evident to the extent that it almost disappears behind the images, but still remains important for the assessment of the comic. The narrative dimension is based on the same dramatization used in literature and in movies to establish a narrative structure, with suspense, events, twists in the plot, and characters with whom we can identify. This refers to the relationship that is established between the readers and the characters, and the extent to which the readers recognize themselves in the characters, start to be interested in them, and thereby experience the story together with the characters. Two examples will illustrate what happens when this dimension is not given careful consideration.

I think it's not only about contents, but also about the characters in comics. If you are interested in a comic, you identify with the characters. But this comic does not even have an introduction. Who are these two characters? That's why I thought it was difficult. I just read it without knowing what it was about (Edward, engineer, CH).

[The characters] would need to be introduced at the beginning of the comic, or there should be an explanatory text. Otherwise, they just exist and the reader has no idea who they are and that's why you just don't care (Inez, high school student visual art/graphics, CH).

Regarding *knowledge transfer*—or matter-of-fact communication—the third dimension, the question of an immediate comprehensibility, emerged as the key criterion for perception. Participants didn't concentrate for minutes on a difficult text segment, asking what it could mean. Confronted with a comic they obviously have a different expectation of comprehensibility, compared to a book with text only. Immediate comprehensibility seems to be a decisive factor in the reader's desire and motivation to further engage in reading a comic.

They talk about "When the input signal is high, the repressor protein is kicked up and that turns off the output signal." I wasn't sure. What are you talking about, input and output? It didn't seem connected to what was previously happening, actually (Amy, graduate student, U.S.).

Even experts in biology couldn't completely understand the information presented in the comic. Only after they were prompted to engage in further research were they able to distinguish between gene technology and the new science of synthetic biology.

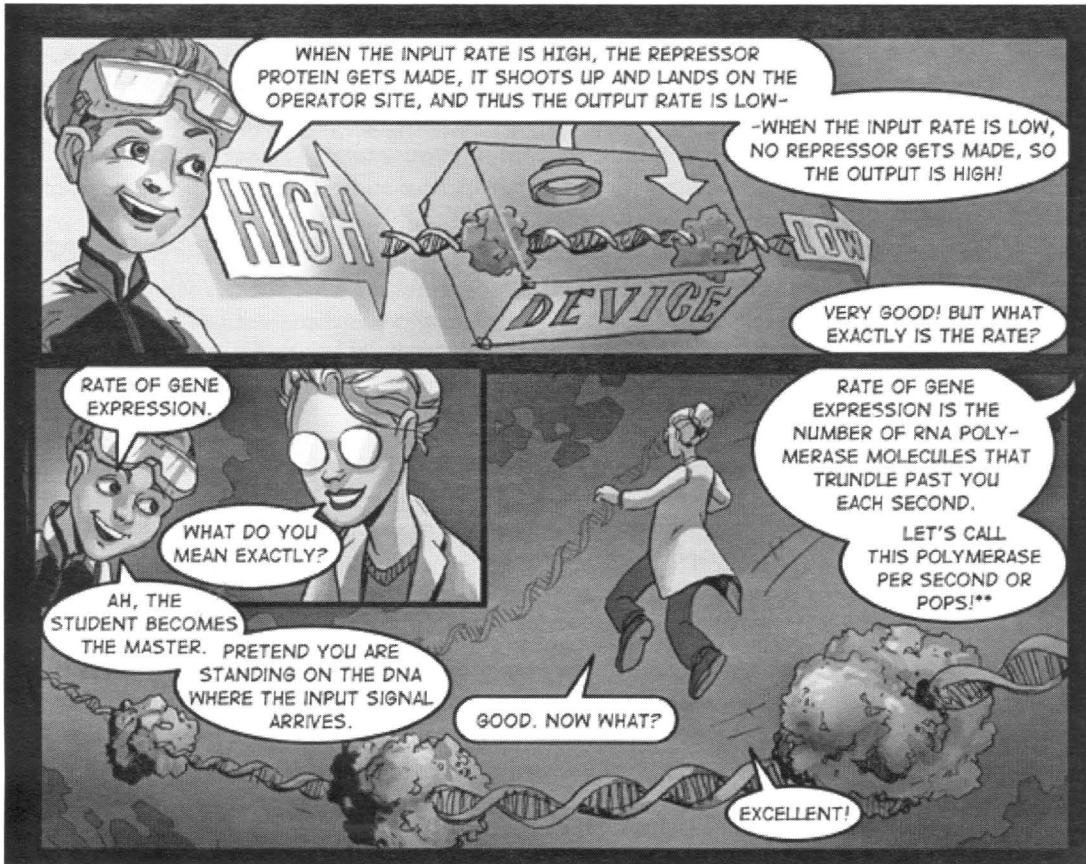


Figure 4. Confusion between scientific content and comic language. From Endy et al. 2005, 11.

Inverter, yes, I can relate to that, height and depth etc., but why we should need this to prevent [the bacterium] from growing, this is something I didn't understand. How is this related to the gene activity that is introduced later on and that we want to stop? (Rita, biologist, CH).

The perception of knowledge and its presentation was the only dimension that was not only identified in all the groups but also assessed with similar negativity.

Processing Visual and Narrative Information

Despite this similar evaluation of the knowledge dimension, each focus group assessed the quality of the other two dimensions differently. For example, their assessment of the visual dimension was by far what most distinguished the Swiss focus groups from the focus group in the U.S. While the discrepancy in their assessments of the narrative dimension was not as strong.

But one of the remarkable results shows that understanding comics is based on a competence that must be learned (by getting familiar with the language of this medium). High school students interpreted the images with reference to the medium itself; they were able to recognize and contextualize comic-specific language. The picture where the bacterium is

about to burst, which, incidentally, is the picture that the Swiss Academy of Sciences believed caused the rejection of the entire comic, provided entertainment for connoisseurs of comics:

I think if it hadn't burst, it would have been even more boring (Elizabeth, high school student visual art/graphics, CH).

You read a comic because everything is totally exaggerated. That's why it didn't bother me that it burst (Lawrence, high school student visual art/graphics, CH).

The broad tendency of the focus group in the U.S. was also to assess the images against the background of the kind of pictures and language typically used in comics. Just like the Swiss high school students, they had internalized the specific competence to decipher the medium and its language. This turned out to be a key requirement to enable successful communication through this medium. The adult experts in Switzerland, however, interpreted the images against the background of the "explosive" topic of gene technology: They perceived them as menacing and deterring.

That's extremely negative. I would never do this. I'd draw the attention elsewhere rather than blow it up and let it burst (Rose, advertiser, CH).

I find the chromosome injection repulsive (Rita, biologist, CH).

Despite their heterogeneity, these results let emerge a "picture" of what caused the obstacles and pitfalls of this comic despite the generally positive attitude toward the comic.

Ambiguity Between Knowledge Combination and Pictorial Message

Our theory based on this investigation is not only that the successful knowledge transfer of an educational comic hinges on the quality of the three message dimensions. The most important factor is the *interaction* among the three dimensions. In other words: Appropriate coherence of the three levels of an educational comic — visual, narration and knowledge transfer — is crucial for the perception of a comic. Unless the reader perceives the three message dimensions as coherent, the comic will not be accepted as a serious or valuable medium for knowledge transfer; instead, it will evoke confusion or even rejection, even if one dimension is recognized as being high-quality (the attractiveness of one dimension seems not to be able to fade out a perceived weakness of another). This relation became evident in the focus groups' discussions, only. Both in terms of country of origin (Switzerland or U.S.) and in terms of generations, the focus groups have shown different perceptions of the coherence of these dimensions.

Because of the naturalness with which they regarded comics, the focus groups in the U.S., who generally had a positive attitude towards this medium, did not seem to have an issue with the interaction among the dimensions. But all the Swiss focus groups were concerned about the lack of coherence, which prompted them to criticize the comic. According to the Swiss sample, the dimension of knowledge transfer contained statements that contradicted both the narrative and the visual dimensions. The perception of this discrepancy not only prompts ambiguity and confusion. It also affects the interpretation of the comic and a reader's motivation to engage in intensive reading:

The pictures are suitable for little kids, but the content is more suitable for our age (Inez, high school student visual art/graphics, CH).

I look at the visuals [and I think] the target population should be kids between ten and 12. But it's too difficult for them anyway (Wanda, graphic artist, CH).

The knowledge that is to be transferred needs to be adjusted to the level of the pictures. The contrast between knowledge and pictures is much too big (Alexandra, high school student visual art/graphics, CH).

Based on this mismatch, the Swiss focus groups kept wondering about the actual target population of the comic. Who had this educational comic been produced for? The readers did not respond to the pictures; rather, they felt degraded, treated as children. As a consequence, the confusion about the highly complex, cognitive messages on the one hand and the child-like pictures on the other hand resulted in the readers' loss of motivation.

The Commingling of Fiction and Reality

The Swiss sample was also confused by the discrepancy between the content level, which is supposed to transfer knowledge, and the narration, which is similar to that of an adventure or fantasy comic.

Due to the entanglement of the content level with the fictional story, the readers, who are not yet experts, have difficulty in distinguishing between fiction and reality when it comes to the interpretation of the messages. This ambiguity about the validity of the content is unsettling for the readers, particularly—but not only—the high school students, who absorb, process, and store information on a daily basis:

There is no way of telling what is real and what is fiction. To check whether it's real what they say, you'd have to look it up in a reference book (Peter, high school student natural sciences, CH).

If the comic seems unrealistic, then you don't think that what the comic says is true (Shannon, high school student natural sciences, CH).

As a layperson, you wonder whether the jargon has been made up (Edward, engineer, CH).

The science fiction genre is just not adequate to deal with this topic. It is confusing too; what's real? It doesn't seem serious (Paul, engineer, CH).

As illustrated by the latter statement, the participant felt that the genre was ill-chosen, both in terms of knowledge transfer and gene research.

In the eyes of the Swiss readers, the adventure genre (with its fantasy elements and strong exaggerations) gives the science of synthetic biology the nimbus of incredibility, of a dangerous, even apocalyptic aura. Graphics experts were surprised by the choice of the genre and how it was put into practice:



Figure 5. This hero appeals to whom? From Endy et al. 2005, 11.

I find it extremely strange, the topic and how it was implemented. That is totally new and unfamiliar for me. The fact that this topic is conveyed in this way is almost a little uncanny, with this kind of language ... with this nonchalance, the easiness with which one reads comics, but this topic is hard to digest (Michael, graphic artist, CH).

If I imagine a more serious style, such as a factual graphic organizer, then [the comic] would get its seriousness back (Ashley, advertiser, CH).

The readers' prejudice against gene research (a horror science that may create strange life forms) is confirmed by this type of narration with its fantastic elements, and thereby promotes a negative attitude in their processing of this new science. The choice of the genre through which knowledge is transferred (an inadequate relationalization of content dimension and visual narration), can affect the publishers' credibility and the perception of their degree of seriousness. This interplay has been a subject of discussion in social psychology (Güttler 1996; Petty and Wegener 1999, 44–57), which asks for further research concerning the acceptance of knowledge transfer presented in information comics.

Conclusion

Why does the interplay among a variety of signal levels or semiotic dimensions constitute a pitfall for the medium of educational comics? We believe that a possible pitfall may be caused by the initial perception of comics as being mainly a visual media. It can be disastrous to focus on one dimension only of the three we have identified, e.g., by presenting appealing images to optimize knowledge presentation, but neglecting narrative elements. Each picture has its own rhetoric, and the use of comic images may disturb a reader who only knows comics from his childhood, in the case of a comic intended to communicate important information to him. In addition to the investigation of whether educational comics are the appropriate medium for the target population, it is important that images, narration, and knowledge constitute a coherent unity for the readers, so that they feel they are being taken seriously. Otherwise, readers will respond neither to the images nor to the narration. Why then should they want to engage with the knowledge that the comic intended to convey?

Unlike comics designed for the purpose of entertainment and art, educational comics have a clear objective: knowledge transfer. If comics are viewed from the angle of art, their openness to interpretation and their richness of allusions constitute a fascinating integral part of this medium. But in educational comics, ambiguity and richness of allusions, even though they can make a comic more appealing, entail dangers: They may confuse readers, even to the extent that they will not know exactly what they are supposed to be learning. Ultimately, the result can be their unwillingness to actively engage with the presented material.

It is rather unlikely that a dictum like the one formulated by Edward Tufte (1983) for the visual display of quantitative information also makes sense in the realm of educational comics: that each spot of paint has a clear, unique meaning. The incorporation of knowledge into a visual narration, where pictures and narration are a medium of knowledge rather than a representation of knowledge, is probably a generic moment of the comic medium itself. Full control over possible meaning is not thinkable, as even theoretical reflections show.

From our perspective, the particular challenge of this medium is the fact that the three

dimensions of communication — visualization, narration, and knowledge communication — are pivotal, and need to be balanced out. This means that they may surprise and amaze the reader, but should not confront him with contradictory messages. It is precisely this balancing act that entails pitfalls. Even if the visualization of the knowledge can be appealing, the reader may not respond well to the narration, may even feel repulsion. Consequently, knowledge acquisition will be impaired.

Whether or not the balancing act was successful is something that may not be predictable by authors and distributors. It only takes small visual details to trigger an unexpected reader response, as we have attempted to exemplify theoretically and empirically. In contrast to a comic intended to be an art form, in the case of educational comics it is necessary to carefully investigate reader perception, for as long as educational comics are not an integral part of learning and even knowledge culture.

Notes

1. “You can use them [educational comics] to teach chemistry; you can even use comics to teach law,” Kakalios enthuses. “Students are so busy enjoying their superhero ice-cream sundae that they don’t notice that I’m sneakily getting them to lower their guard and eat their spinach at the same time” (Gerstner 2003).

2. We assume that this applies to all German-speaking readers. We hope to include French-speaking cultures, where the art of comics is much more deeply anchored, in our next investigation.

3. Today, he is an assistant professor in the Department of Bioengineering at Stanford University.

4. Cf., concerning the background: http://openwetware.org/wiki/Adventure_Background.

5. The tabloid *Blick* is comparable to the British newspaper *The Sun* or *The Globe* in the U.S.

6. In contrast, there are, as for example Martin Jay showed, historic different “scopic regimes,” different ways of seeing and interpreting images (Jay 1988). Even the development of new media techniques (Crary 1992) affects how the recipients perceive sequential picture-stories.

7. Especially biology, showing the complex form of organisms, has profited from this advance of the connotative power of combining text and image since more than hundred and twenty years ago, for example with class wall charts to teach a great mass of children with no educational background for the first time (Bucchi 2006).

8. In a large-scale survey carried out in February 2010 to measure people’s knowledge about this new technology in Europe, 83 percent of all respondents reported that they had never heard of “synthetic biology.” Eight percent said that they had come across this term before and only eight percent stated that they had concerned themselves with this topic (Gaskell et al. 2010, 29).

9. This is the domain of cultural studies as the study of “cultural representation and signifying practices,” which is not the primary subject here. See Hall (1997).

10. See the broad discussion of various ways to define the educational comic in: Jüngst (2010, 11f).

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