

Linek, Stephanie B.; Huff, Markus

Conference Paper

Serious comics: a new approach for science communication and learning

Suggested Citation: Linek, Stephanie B.; Huff, Markus (2018) : Serious comics: a new approach for science communication and learning, In: Proceedings of the 12th International Technology, Education and Development Conference (INTED 2018), 5th - 7th March, 2018, Valencia, Spain, ISBN 978-84-697-9480-7, IATED Academy, Valencia, pp. 3883-3890

This Version is available at:
<http://hdl.handle.net/11108/355>

Kontakt/Contact

ZBW – Leibniz-Informationszentrum Wirtschaft/Leibniz Information Centre for Economics
Düsternbrooker Weg 120
24105 Kiel (Germany)
E-Mail: info@zbw.eu
<https://www.zbw.eu/de/ueber-uns/profil-der-zbw/veroeffentlichungen-zbw>

Standard-Nutzungsbedingungen:

Dieses Dokument darf zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden. Sie dürfen dieses Dokument nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, aufführen, vertreiben oder anderweitig nutzen. Sofern für das Dokument eine Open-Content-Lizenz verwendet wurde, so gelten abweichend von diesen Nutzungsbedingungen die in der Lizenz gewährten Nutzungsrechte.

Terms of use:

This document may be saved and copied for your personal and scholarly purposes. You are not to copy it for public or commercial purposes, to exhibit the document in public, to perform, distribute or otherwise use the document in public. If the document is made available under a Creative Commons Licence you may exercise further usage rights as specified in the licence.

SERIOUS COMICS: A NEW APPROACH FOR SCIENCE COMMUNICATION AND LEARNING

Stephanie B. Linek¹, Markus Huff²

¹ZBW – Leibniz Information Centre for Economics (GERMANY)

²DIE - German Institute for Adult Education (GERMANY)

Abstract

This paper presents a new approach called serious comics. It combines the long-term trend to infotainment, edutainment, and gamification with the rising importance of graphics in Web 2.0 and in science communication. Thereby, serious comics are understood in analogy to serious games. According to our definition, serious comics make use of the language of comics for science communication, academic information, and learning. The language of comics is unique in several ways. The combination of words and pictures served a mutual understanding and there are fluent boundaries between words and pictures. For example, the way words are depicted (e.g., shape, size, and color) added surplus meaning (e.g., emotion, loudness). Thereby, in comics words can portray pictorial aspects and pictures can represent verbal aspects.

The idea of using graphic novels in academia is not new. However, until now the approaches are rather pragmatic without scientific foundation. In comparison, our approach of serious comics offers a systematic and scientifically founded view of the use of comics for academia in general including science communication, open science and citizen science as well as educational purposes.

In this contribution, we introduce the concept of serious comics and provide a short definition and description of the context. Furthermore, we explore relevant existing related approaches and empirical findings. For instance, research on narrative understanding of (entertaining) conventional comics has provided important scientific insights in the understanding of unfolding pictorial events. As an example, actively acting characters (“agents”) are processed prioritized over characters receiving the action (“patient”). Thus, the semantic structure of an image determines comprehension processes. Additionally, many instructional principles (e.g., spatial contiguity principle, i.e., the verbal explanations should be placed near to the related picture) from educational psychology research can be applied to serious comics as well. In addition, findings on serious games (e.g., design of game characters) can deliver useful insight on serious comics.

After the definition of serious comics and the description of related research, we provide a systematic classification of serious comics (in relation to other approaches) that considers two dimensions: The first dimension relates to the used elements, i.e., the combination of words and pictures and the modality of representation (auditory, visual). The second dimension differentiates between conventional information delivery, infotainment, and entertainment.

Subsequently, we illustrate advantages (e.g., appealing young scientists) and limitations (e.g., risk of oversimplification) of serious comics. Furthermore, we provide an overview of possible application fields besides learning, e.g., for science communication, open science, and citizen science. Also, we identify important open research questions on serious comics. The paper closes with a short resume.

Keywords: Serious comics, infotainment, science communication, learning.

1 INTRODUCTION AND BACKGROUND

“A picture is worth a thousand words” - this proverb implies an advantage of graphical illustrations over verbatim or text-based statements. Indeed, human memory for pictures is extremely high and precise. Additionally, there is a long-term trend to “edutainment” and “gamification” that is independent of the information channel and media source. Taking together, information is more appealing to potential readers when it includes some graphics and entertaining aspects. Against this background, it is not surprising that it is increasingly common to use graphical information for communicating scientific information. Based on these considerations we propose a new approach called “serious comics”.

1.1 Serious Comics: Definition and Context

1.1.1 Definition

We define serious comics as a combination of pictures and written text that makes use of the art form and unique language of comics for an entertaining and appealing communication of academic information. This also includes learning. Thereby, serious comics are conceptualized in analogy to serious games.

Serious comics can be seen as a special mixture of linear multimedia instructions or infographics on the one hand and entertaining comics at the other hand. Serious comics exploit the entertaining potential (art form) and unique language of comics to make scientific information more appealing with respect to communication and learning (Fig.1).

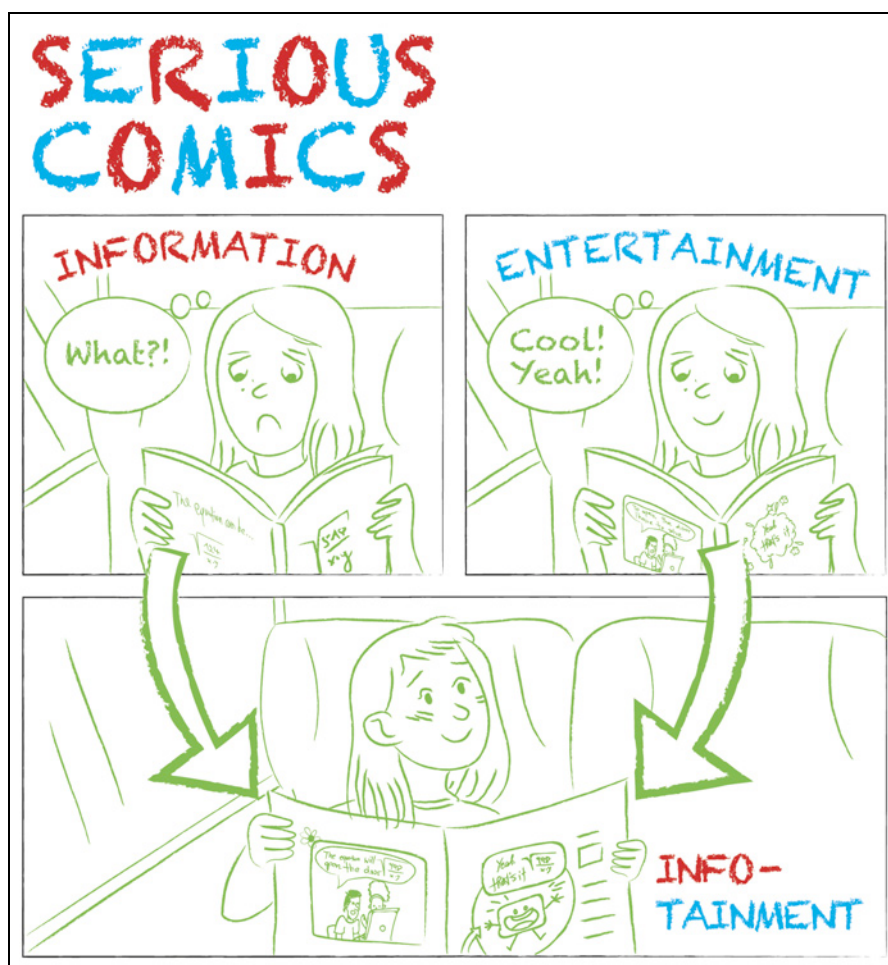


Figure 1. Visualization of serious comics.

Remark: This visualization is *not* an example of a serious comic, because it includes neither artistic graphics nor the characteristic language of comics.

We understand the term “language of comics” as a short label for the language and grammar of the sequential art and visual narratives as described in instructional textbooks for comics by e.g., Will Eisner [1, 2] or Scott McCloud [3]. The language of comics is unique in several ways. The combination of words and pictures served a mutual understanding and there are fluent boundaries between words and pictures. For example, the way words are depicted (shape, size, and color) added surplus meaning (emotion, loudness ...). Thereby, the words can be pictures - and pictures can serve as words.

The language of comics can be used to communicate scientific findings in a fast, motivating, and entertaining way. Similar, serious comics can be also the basis to provide educational content to learners (from the view of the teachers): the educational and academic idea behind is very similar to

graphical abstracts in scientific literature and multimedia instruction, however in a more entertaining and appealing way.

Our definition understands serious comics in a very broad sense, that is, we also include single-panels of comics (= one scene within an extended picture that includes simultaneous or sequential events) or cartoons (single pictures) that could be denoted more precisely as serious cartoons (serious comics in a broader sense). Serious comics in a narrow sense include several panels that are combined with a storyline.

It is important to note that the overall research aim is *not* about the design of graphics. Rather, we aim to investigating the art form and language of comics as extension and playful version of academic communication (including learning).

Thereby, our definition excludes some special cases:

- Serious comics are different from illustrated gap texts and similar exercises. Also, simple tasks and games like sudoku are not serious comics, because they do not use the language of comics and do not provide (educational or scientific) information (but rather can be seen as kind of entertaining exercise).
- Serious comics differentiate from illustrated academic textbooks. The graphics of serious comics are more than just decoration. Rather, serious comics comprise joyful graphics (analogous to the art form of conventional comics) that serve enjoyment as well as understanding.
- Serious comics are more than just using conventional comics for a different purpose, e.g., if a usual comic is presented in a foreign language (in order to foster language learning) it is not a serious comic, because it lacks the scientific and educational basis. However, conventional comics could be the basis of serious comics if such conventional comics are modified in a way that the foreign language is stronger integrated in the storyline, e.g., frequent made language misconceptions are discussed between the heroes of the comics. (This might be a very good use case in the context of migration and refugees see section on context and section on application areas.)
- Serious comics are different from conventional comics that use scientific-related or educational-related facts as cover story. For example, several Disney comics use a historic or science-related cover story (titles like “Duck-Ench-Amon”). Similar, the series “The adventures of Tintin” is often embedded in a story that included foreign countries and local customs. Also stories on Superheroes like “Flash” are based on more or less specious scientific arguments. Even though such comics might motivate the reader to deal with science or the concerned educational contents, the comics themselves serve no scientific or educational purposes and the presented information is not scientifically proven. The same is true for caricatures or cartoons on politics, history or science-related contents. Nevertheless, such comics and cartoons can be seen as a kind of unproven prototype how scientific information might be presented in a funny way and thus, can serve as a starting point for creating serious comics.

1.1.2 Context

Humans can remember an extraordinarily large number of pictures as compared to auditory information [4]. Further, humans prefer looking at pictures as compared to texts [5]. Also in social media (Twitter, Instagram) there is a trend to use graphics instead of text (partly due to the limitations of word count). Thus, it is not surprising that it is increasingly common to use graphical information and graphic novels / comics in education and scientific communication.

Besides the attempts to use graphic novels for classroom learning (e.g., <https://www.nostarch.com/catalog/manga>) and to teach visual literacy (e.g. [6]) there are also examples how to use comics for science communication: Some scientific journals require the authors to design a graphical abstract that is then used for promotion of the scientific paper and/or communicating its results. Partly, also the possibility of cartoon abstracts is provided (<http://explore.tandfonline.com/page/est/cartoon-abstracts>). Additionally, there are also several first initiatives to provide scientific information in form of comics: The scientific journal Nature provides a comic on climate change (<http://www.nature.com/news/the-fragile-framework-1.18861>). Similarly, there are scientific journals that provide some articles in form of comics (e.g., on the marine socio-ecological system: <https://academic.oup.com/icesjms/article/74/7/1965/3058980>). Furthermore, some university departments offer their students scientific information in form of comics (e.g., on parasitology <https://www.gla.ac.uk/researchinstitutes/iii/>

wtmp/publicengagement/wtmpcomics/ or on viruses <http://worldofviruses.unl.edu/comics-apps/>). Additionally, there are also some projects that explicitly aim at the use of comics for science communication (e.g., <http://margreetdeheer.com/eng/science.html>, <https://www.erccomics.com/>, https://www.logicomix.com/en/index8be8.html?option=com_content&view=frontpage&Itemid=53).

These examples and initiatives are (at least partly) examples of serious comics or serious cartoons, respectively. However, they are rather pragmatic attempts to use the art form and language of comics for learning and science communication. Our approach on serious comics aims at a framework that enables a more systematic, theoretically founded, and empirically based investigation of comics in science and education.

1.2 Prior Related Research on Comics, Conventional Instructional Design, and Infotainment

The concept of serious comics refers to the narrative structure and unique language of comics, the design of educational instructions, and edutainment. In the following, we provide a short exemplarily overview on existing related approaches that can be useful for serious comics. Within the scope and the limited space of this contribution we focus on the most relevant theoretical concepts and empirical findings that, from our point of view, are applicable to the concept of serious comics.

1.2.1 Existing Theories and Research on Comics and Visual Language

To date, comic research predominantly focuses on the aspects of how a narration is depicted in a sequence of pictures and how recipients understand the narration. The plot depicted in comics is based on multiple actions that unfold over time and images, consequently. Actions in comics comprise an agent (i.e., a person performing an action) and a patient (i.e., a person receiving the action). As an example, in a picture depicting Lucy punching Charlie Brown, Lucy is the agent and Charlie Brown the patient. Research has shown that agent information is prioritized over patient information [7] and eventually helps to perceive a coherent structure across multiple pictures [8]. The process of narrative understanding across an image sequence is thought to be a combination of laying the foundation of a mental representation when perceiving the first image and updating this mental representation as new information from the subsequent images is processed [9, 10]. The mental representation of the depicted event is the basis for comprehension. Using uni-codal (i.e. just visual or just text-based) narrations, this process is conceptualized as being independent of the used codality.

Taken together, it could be assumed that for the proper understanding of serious comics it is important that the first image depicts adequate information thus laying the foundation of the mental representation. The subsequent panels of a serious comic should then provide additional information that can be used to update and enrich the initial mental representation. On the other hand, it can be argued that an ambiguous or partly confusing initial image-sequence (like it is partly the case for conventional comics or entertaining movies) might be used to evoke curiosity and encourage the learner to question what they see. It is an open research question if this process could be especially helpful for the deeper understanding of complex information.

1.2.2 Instructional Design: What can be Helpful for Serious Comics

Evidence from communication science [11] and educational psychology [12] allows us to describe boundary conditions of successful use of serious comics. When it comes to communicating scientific results with serious comics several aspects of both the message and the potential addressee have to be considered. The central assumption of the theoretical models is that recipients have a limited capacity for information processing [11, 12] and those characteristics of the recipients (e.g., prior knowledge, motivation to process information) and the message (e.g., picture based vs. combination of picture and text information) have to be considered. Thereby, principles of instructional design can be also helpful how to combine words and pictures. For example, the spatial contiguity principle [12] suggests that words have to be placed near to the related (part of the) picture. Furthermore, according to the personalization principle [13] instructions should be given in a personalized way (using “I” and “you” and active descriptions) instead of a formal style (using “it” and passive descriptions). Such instructional principles can also be used if explanations are given in form of serious comics.

1.2.3 Infotainment, Gamification, and Entertainment: Prior Research Applicable for Serious Comics

Infotainment and gamification are based on a socio-motivational enhanced view of interacting with media. The so-called media equation [14] is an early attempt that states that “media are equal real” and thus, the interaction with media “is fundamental social and natural” [14: p. 5]. That means humans apply the same social principles to media including gender stereotypes, politeness rules or similarity attraction (i.e., people prefer people that are similar to themselves). There is broad empirical evidence on the media equation [14] that can be applied to the design of media and especially media characters. For example, the similarity attraction principle can be applied to game characters, i.e., players prefer (non-player characters) that have similar personality characteristics [15]. Similar, there is also existing research on the identification with media characters in general [16]. In relation to (serious) comics, these findings can be used to create comic characters and heroes/heroines that maximize the enjoyment of the readers. Similar, also many findings on serious games (overview is given by [17], see also [18]) can be useful for serious comics, too.

Taken together, evidence from research on comics, instructional design, and infotainment/gamification provides important insights for designing serious comics that communicate academic information.

2 SERIOUS COMICS: A CLASSIFICATION

The idea of using comics for learning is not completely new and in the paragraph above (definition and context of serious comics) we provided several examples on first attempts how to use comics in science communication and education.

However, such approaches were rather pragmatic and its claims often not empirically founded. Our concept of serious comics is based on a more scientific and systematic view. Against the background of prior research and theories on instructional design, infotainment/ gamification and entertainment, we want to combine the motivational potential and the unique art form and language of comics with existing models and empirical findings on academic communication and instructional design. This provides the base for a scientific empirically based investigation of serious comics.

For a thematic and structural overview of serious comics we propose a systematic classification of media that include a combination of pictures and words. The proposed classification excludes media that uses only words (e.g., simple text books, spoken instruction, belletristic) and media that uses only pictures (e.g., text-free visualizations, paintings), because the symbiosis of words and pictures is an essential characteristic of the unique language of comics.

Our proposed classification considers two dimensions (see table 1): The first dimension relates to the used elements, i.e., the combination of words and pictures and the modality of representation (auditory, visual). The second dimension relates to the entertaining potential and differentiates between conventional information delivery, infotainment and entertainment. Accordingly, the first dimension (used elements) relates more to the cognitive aspects of information processing and the second dimension (entertaining potential) is connected more to the motivational processes and the entertaining appeal.

Table 1. Systematic classification of serious comics.

	Conventional information delivery	Infotainment	Entertainment
Single picture with single or combined information (written form)	Infographics; instructional graphics; graphical abstracts	Serious comics in the broader sense: serious cartoons	Cartoons; single panels within a comic
Multiple pictures with multiple information (written form) that is connected by narratives or a kind of storyline	Multimedia materials for science communication and multimedia learning: instructions with pictures and written text	Serious comics in the narrower sense	Entertaining conventional comics
Video that combined audiovisual information by narratives or a storyline	Multimedia learning: audiovisual instructions (with videos and spoken text)	Entertaining documentations; movies for edutainment; science shows etc.	Animated films / movies
Interactive environment	Interactive e-learning platforms and applications	Serious games (game-based learning)	Games

Roughly spoken, it can be assumed that the underlying cognitive processes of information processing (for each rows) are very similar, however, the motivational appeal and the enjoyment increases gradually (along the columns from left to right).

Even though the table includes many examples from the field of educational research, it is important to note that serious comics are not restricted to learning but should be seen in the broader context of information processing and communication (i.e., communication within the research community and in science). A non-exhaustive list of examples for application fields of serious comics includes science communication, citizen science, and open science in general. In the next section we will provide further details on possible application fields of serious comics.

3 APPLICATION OF SERIOUS COMICS

For the application of serious comics it is important to consider their advantages and limitations. Accordingly, this section explores the application fields of serious comics in relation to their special characteristics.

3.1 Advantages and Limitations of Serious Comics

3.1.1 Advantages

The most obvious advantage is the higher *motivational potential in form of infotainment*. On the one hand pictures are appealing and increase the probability that an accompanying text is read. On the other hand, serious comics use the entertaining elements of comics, and thus, provide information in an entertaining way (e.g., funny characters, appealing storyline, artistic design). Due to their higher motivational appeal, serious comics are a way for attracting and fostering the interest of young scientists, scientific offsprings, and students.

Furthermore, serious comics can be designed in a more *concise* way and thus, work well for media that allow only short text (e.g., Twitter). This enables also faster information delivery. Beyond that, the conciseness of the language of comics forces the creator to be very *clear* in the presentation of the content (at the cost of the danger of "oversimplification"). This conciseness and clarity in turn might promote interdisciplinary discourse and research.

In comparison to other media using graphics like games or animations, a *more universal application* is possible, because the technical requirements are lower and serious comics can be provided in a computer-based as well as in a printed format.

Additionally, the visual language of comics has the potential to *overcome language barriers* (universality of pictures, graphical abstracts need only minor translation). Thereby, serious comics can promote international exchange of research and can foster also citizen science.

Similarly, serious comics can be used for *overcoming barriers of education* (extreme case: illiteracy).

Overall, the higher motivational potential and the potential to overcome barriers of education are perfect conditions for *opening science* for society and the broad public. Thus, serious comics are a promising way for the communication of research with social relevance for the public.

3.1.2 Limitations

Besides the long list of advantages, there are also several limitations of serious comics. First and foremost, the crucial prerequisites to develop serious comics are *technical and artistic skills* to design graphics, *educational skills* to provide graphics in an informative form, and *creative skills* to make graphics entertaining. Thus, it is advantageous to create serious comics by help of an interdisciplinary team (educators, psychologist, artist, ...) or at least have team members with the additional necessary skills.

Another limitation of serious comics relate to *complex information* and relations which are partly hard to communicate via pictures and the language of comics. However, there are first promising attempts how also complex information can be presented in the form of serious comics (https://www.logicomix.com/en/index8be8.html?option=com_content&view=frontpage&Itemid=53).

Nevertheless, serious comics inherit the *danger of oversimplification* and that the artistic comic elements might *distract from learning*. Thus, applications of serious comics need to account for these possibly interfering effects.

3.2 Application Areas for Serious Comics

The description of the advantages and limitations of serious comics provides the basis for the identification of the main application areas.

Serious comics are well apt for motivating *education* (edutainment), including classroom learning and lifelong learning. Thereby, the visual language of serious comics seems to be especially promising for language learning (by providing additional pictorial information) and teaching (functional) illiterate people.

Another broad application field is the *academic communication* between researchers, especially the science communication via Web 2.0 because serious comics can overcome technical restrictions and limitations to short messages (e.g., character limitation on Twitter). Additionally, the use of pictures and the potential for more conciseness and clarity prevents misunderstandings. Besides, the appeal of serious comics can be used for fostering the next generation of scientists.

Similarly, *citizen science* is a promising application field. Serious comics can lower the barriers of participation (by overcoming language barriers and barriers of education) and enhance the motivation to take part in the citizen science movement, consequently. Furthermore, citizen science can provide a connection point for the collaboration between science and arts. Like pointed out in the section on advantages and limitations, a crucial bottleneck of serious comics is the necessity of technical and artistic as well as educational and creative skills. Accordingly, within a citizen science project it is possible to address not only interested (hobby) researchers but also (hobby) artists.

Finally, serious comics can be applied for *opening science for the broad society*. The motivational appeal and the universality of pictures (overcoming barriers of education) together with the higher conciseness and clarity of serious comics are good initial conditions to reach out to the broad public.

4 SERIOUS COMICS: A POSSIBLE RESEARCH AGENDA

So far, there is no systematic research on serious comics and thus, there is a broad field of open research questions. Within this section we will exemplarily describe some of the most elementary and important open questions that hopefully will inspire researchers in the future. From our point of view, research on serious comics should focus on design, information processing, and educational aspects. Importantly, to get a comprehensive picture these research questions require interdisciplinary research teams.

With regard to the design of comics, research should work on establishing design guidelines for serious comics. For example, these guidelines should make suggestions about the adequate amount of information in a panel or information on how to implement a story line in serious comics. This should start with a corpus analysis to get an overview of the field of serious comics. Based on the results of this corpus analysis it is possible to realize first tests of different forms of serious comics. Such initial tests should primarily focus on user centered aspects (generating interest, motivation, learning, voluntary spent learning time) of serious comics. In a next step, scientists (such as psychologists, linguists, and educators), domain experts (e.g., biologists for a serious comic about a biological process), and comic artists should collaborate on establishing, implementing, and evaluating the guidelines. This guarantees that the serious comics depicting a certain scientific procedure, result, or principle can be understood and are scientifically sound.

After having established serious comics in the field, this project also offers promising research opportunities for computer scientists. Social network analysis techniques could be used to study the outreach of serious comics on the internet. As an example, it would be interesting to examine the sustainability of serious comics in science communication and learning. That is, serious comics should not only attract readers' attention but also increase information search activity in the corresponding academic domain.

5 RESUME

Within this contribution we described serious comics as a new approach for science communication and learning. Serious comics make use of the art form and unique language of comics for academic information and thus, can be suggested as a promising new way in academia. Even though serious comics can exploit partly research of other related areas, it is a distinct approach. The definition and

systematic classification of serious comics provides a clear differentiation to other areas that investigate the combination of pictures and words.

Based on the advantages and limitation of serious comics we have described some important application areas in the future. Finally, we have presented a possible research agenda. We hope, we inspire other researcher and serious comics will promote science communication, education, and open science.

REFERENCES

- [1] W. Eisner, *Comics and Sequential Art*. New York: W.W. Norton & Company, 2008.
- [2] W. Eisner, *Graphic Storytelling and Visual Narrative*. New York: W.W. Norton & Company, 2008.
- [3] S. McCloud, *Understanding Comics*. Tundra Publishing, 1993.
- [4] M. A. Cohen, T. S. Horowitz, and J. M. Wolfe, "Auditory recognition memory is inferior to visual recognition memory," *PNAS*, vol. 106, pp. 6008–6010, 2009.
- [5] K. Rayner, B. Miller, and C. M. Rotello, "Eye movements when looking at print advertisements: The goal of the viewer matters," *Applied Cognitive Psychology*, vol. 22, no. 5, pp. 697–707, 2008. <https://doi.org/10.1002/acp.1389>. [Accessed December 20, 2017].
- [6] N. Frey and D. Fisher, Eds., *Teaching Visual Literacy*. Thousand Oaks, CA: Corwin Press, 2008.
- [7] N. S. Segalowitz, "The perception of semantic relations in pictures," *Memory & Cognition*, vol. 10, no. 4, pp. 381–388, 1982. <https://doi.org/10.3758/BF03202430>. [Accessed December 20, 2017].
- [8] N. Cohn and M. Paczynski, "Prediction, events, and the advantage of Agents: The processing of semantic roles in visual narrative," *Cognitive Psychology*, vol. 67, no. 3, pp. 73–97, 2013. Available: <https://doi.org/10.1016/j.cogpsych.2013.07.002>. [Accessed December 20, 2017].
- [9] N. Cohn, "Visual narrative structure," *Cognitive Science*, vol. 37, no. 3, pp. 413–452, 2013.
- [10] M. A. Gernsbacher, K. R. Varner, and M. E. Faust, "Investigating differences in general comprehension skill," *Journal of Experimental Psychology: Learning, Memory, and Cognition*, vol. 16, no. 3, pp. 430–445, 1990. Available: <https://doi.org/10.1037/0278-7393.16.3.430>. [Accessed December 20, 2017].
- [11] A. Lang, "The limited capacity model of mediated message processing," *Journal of Communication*, vol. 50, no. 1, pp. 46–70, 2000. Available: <https://doi.org/10.1111/j.1460-2466.2000.tb02833.x>. [Accessed December 20, 2017].
- [12] R. E. Mayer, *Multimedia Learning*. New York: Cambridge University Press, 2001.
- [13] R. Moreno and R. E. Mayer, "Engaging students in active learning: The case for personalized multimedia messages," *Journal of Educational Psychology*, vol. 92, pp. 724–733, 2000.
- [14] B. Reeves and C. Nass, *The Media Equation*. Stanford, CA: CSLI Publications, 1996.
- [15] S. B. Linek, D. Schwarz, G. Hirschberg, M. Kickmeier-Rust, and D. Albert, "Designing the non-player character of an educational adventure-game: The role of personality, naturalism, and color," In *Proceedings of the International Technology, Education and Development Conference (INTED)*, Valencia, Spain, 2007.
- [16] J. Cohen, "Audience identification with media characters," in *Psychology of Entertainment*, J. Bryant and P. Vorderer, Eds. Mahwah, New Jersey: Lawrence Erlbaum Associates, 2006, pp.183-197.
- [17] T. Hainley, T. M. Connolly, E. A. Boyle, A. Wilson, and A. Razak, "A systematic literature review of game-based learning empirical evidence in primary education," *Computers & Education*, vol. 102, pp. 202–223, 2016.
- [18] S. B. Linek, "As you like it: What media psychology can tell us about educational game design," in *Handbook of Research on Improving Learning and Motivation Through Educational Games: Multidisciplinary Approaches*, P. Felicia, Ed. IGI Global, 2011, pp. 606 – 632.