Research Journal of Applied Sciences, Engineering and Technology 7(19): 4106-4114, 2014
DOI:10.19026/rjaset.7.774
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: December 13, 2013 Accepted: December 23, 2013 Published: May 15, 2014

Research Article

Engineering Graphics Education: Webcomics as a Tool to Improve Weaker Students' Motivation

Riccardo Metraglia and Valerio Villa
Department of Mechanical and Industrial Engineering, University of Brescia, Brescia, Italy

Abstract: In engineering colleges, first-year students come from different kinds of high school and have different technical backgrounds. In engineering graphics courses, the weaker students are the ones entering with a lower technical background. Such students are less motivated and have generally difficulties in keeping high their attention level during the lessons. In this study, the use of a webcomics structured in graphic novels was experimented as a motivational support in an engineering graphics course. Sixty nine students of a class taught by using webcomics as support and 47 students of a class taught traditionally were classified according to the kind of their high school of provenience: technical; scientific; non-technical and non-scientific. The findings showed that in the class where webcomics were used, students from non-technical and non-scientific high school scored a higher level of attention compared to others. The teacher who used the webcomics commented it an effective tool to encourage and stimulate weaker learners to actively participate to the lessons and the majority of students agreed such tool was stimulating. At the same time, some students considered the webcomics representation of engineering graphics topics as too far from the reality. It is concluded that the use of webcomics structured in graphic novels is a proficient way to better motivate weaker students to arouse and keep their attention at a high level during engineering graphics lessons.

Keywords: Comic strips, engineering education, graphic novels, teaching, technical drawing

INTRODUCTION

Webcomics are acknowledged to be an important educational instrument to motivate students (Yang, 2003b). Motivation is particularly important for students who are weaker or have fear of failure (Koenke, 1981, as cited in Yang, 2003b; Keller, 2006b). In engineering graphics courses at engineering colleges, freshers generally come from different high schools and have different technical backgrounds when beginning the program (Metraglia *et al*., 2011, 2013; Salas-Morera *et al*., 2013). Students from non-tecnical schools tend to have less attention during the lessons the more they feel the treated topics are too complicated. To try to motivate such weaker students to keep high their attention level, the authors designed a webcomics to be used during the course as a support in engineering graphics lectures topics and to test the webcomics' effects on students' motivation.

LITERATURE REVIEW

History of comics in education: The first attempts of using comics in education are generally referred to the 40's of the twentieth century and to Sones (1944, as cited in Yang, 2003a) in particular. The idea of using strips and comics as a tool to help teaching has actually a longer history. In the Middle Age, some Christian churches used mosaics, pictures and sculptures to create a sort of comics strips illustrating the most important moments cited in the Bible. The aim was to support the priest during his preaching to the people, whose majority was illiterate and had not the opportunity to have a book. That visual representation was jus called *Biblia pauperum*, i.e., "paupers' Bible" (McLuhan and Lapham, 1994). Despite the beginning of using comics in education dates back so long ago, after the attempts of the 40's, comics have been recovered importance in education just since the 90's, especially in the United States (Yang, 2003a) and Europe (Retalis, 2008). Several comics and digital comics (webcomics) were designed and used as a support in science education, as reported by Tatalovic (2009) and particularly in high schools (Retalis, 2008). Studies were conducted on courses such as: English (Williams, 1995; Versaci, 2001; Gibson, 2007, as cited in Retalis, 2008), Physics and Chemistry (Kakalios, 2002), History (Chilcoal, 1993, as cited in Retalis, 2008), Biology (Hosler and Boomer, 2011).

Comics as a tool to help weakers' education: Most of these comics aimed to help inexperienced people in increasing their knowledge or skills by using a light educational approach. Comics can in fact serve as an

Corresponding Author: Riccardo Metraglia, Department of Mechanical and Industrial Engineering, University of Brescia, Brescia, Italy

intermediate step to difficult disciplines and concepts (Yang, 2003b; Hosler and Boomer, 2011). However, the most frequently cited benefit of comics in education is its ability to motivate students (Yang, 2003b). In their literature review, Hosler and Boomer (2011) argued that despite a number of published articles about experiences in using comics in education to motivate students, no estimate of the role comics plays had been measured by scientific experiments. In the last years, some experiments were conducted and their findings supported the idea that comics (especially webcomics) are an important instrument in education, especially for weakers. Hosler and Boomer (2011) found that webcomics had a positive role in biology education, particularly more convincing among non-majors and weaker biology majors than among strong biology majors. Salehi *et al*. (2012), about teaching students how to write in English, wrote that the use of digital comics was a very effective way to teach students who had low proficiency in the English language and that it was a valid instrument to build those student's motivation. However, in both the studies, the researchers argued that webcomics could result inappropriate or little effective in advanced learners' education. An explanation of why webcomics are so appreciated by weakers could be that educational texts are perceived, by definition, as abstract and unconnected to students' everyday lives (Norton, 2003), whilst comic strips and comic books reflect more an authentic language and culture (Davis, 1997). About the use of comics in education, Norton (2003) observed that adults and teachers in particular, are often dismissive of comic books. He argued that an explanation of such behavior could be the adults' fear of losing in some way control over students. However, Salehi *et al*. (2012) reported positive comments of educators on the use of webcomics in teaching to low-achieving learners. Particularly, educators actually considered webcomics as a tool to attract and encourage weakers to actively participate to the lessons, "transforming the job of learning into a more enjoyable experience". Educators also considered the webcomics an easy tool to use and they were willing to use webcomics in their didactics beyond that experimental study.

Webcomics as a motivational instrument in engineering graphics education: Introductory first-year courses as engineering graphics are imperative to spark student interest in engineering and need to be designed for students with varying interests and different levels of technical background (Dutta and Haubold, 2007). To develop tools to motivate freshers at engineering graphics courses and to maintain their attention in such a course is important (Contero *et al*., 2005; Ernst and Clark, 2012), especially for the weakers, who are generally the students missing a technical background because of the non-technicality of their high school of provenience. Such students are likely to find more difficulties than others at the beginning in an engineering college and they are the most subjected to drop out in the first years. An acknowledged problem is their lack of motivation (Baillie and Fitzgerald, 2000). That lack of motivation reflects also in engineering graphics courses that are generally dispensed in the first years of the engineering college. Ernst and Clark (2012) found no significant relationships between motivation to learn and student attitudes toward engineering and technical graphics. However, at the University of Brescia, engineering graphics teachers affirmed (anecdotally) that it seems that the more students with a poor technical background feel the topics treated during the lectures get too complicated, the less they keep high their attention level, missing by that some knowledge crucial to pass the exam. Despite previous studies experimented webcomics as a motivational tool in several areas, no experiments on using webcomics as a support to teach engineering graphics to freshers have been conducted yet.

A webcomics for engineering graphics education: "The adventures of Mr. Clumsy, the engineer": To explore the role of webcomics as a motivational instrument in engineering graphics courses, it was created a webcomics ad hoc for the engineering graphics course taught at the University of Brescia. The idea of the webcomics was to narrate a story using comic strips and graphic novels, indicated by Zimmerman (2010) as an efficient and effective way to use comics in education and successfully used by Hosler and Boomer (2011) in biology, who reported that the "graphic novel approach" was positively received among non-majors beginning a course with lower content knowledge. The theoretical approach in designing the webcomics was based on Keller's ARCS model (Keller, 1987a, b, c). Keller argued that to develop learner motivation, a teaching approach or a tool should be focused on one or more of the four categories (A)ttention, (R)elevance, (C)onfidence and (S)atisfaction. The first step of promoting and sustaining motivation is to gain 'Attention'. According to Keller's ARCS model, Attention can be gained in two ways:

- Using surprising and novel events to gain interest
- Stimulating curiosity by posing challenging questions and by varying the elements of instruction

Among the suggestions to grab the learners' attention, Keller indicated: to use a visual stimuli or a story; to involve the learners with games or other simulation allowing them to get involved with the subject matter; to use humor to break up monotony and

maintain interest (Keller and Suzuki, 1988). Basing on this model, the webcomics "The adventures of Mr. Clumsy, the engineer" was designed-the original webcomic was in Italian, titled "le avventure dell'ingegner Maldestri". "The adventures of Mr. Clumsy, the engineer" was a series of short graphic novels, each one introducing the topic of an engineering graphics course lecture. In the novels, Mr. Clumsy faces several problems about engineering graphics. The character's approach to solve such problems is just 'clumsy' and he usually gets into trouble with technicians that find several mistakes or failings in his technical drawings. At the end of every tale he is always suggested to attend the engineering graphics course theoretical lesson to fill his gap of knowledge.

According to the review of Retalis (2008), the studies conducted concerned the teaching of a foreign language supported by webcomics were generally successful. To teach engineering graphics was argued by Metraglia *et al*. (2011) to be similar to teaching a foreign language. In effect, as it happens in a language education, in engineering graphics you learn words' meaning and pronunciation (so, engineering graphics rules and regulations), how to build sentences (so, to design technical drawings for specific goals) and how to use such sentences to interact with the world around (so, to solve problems by technical drawing design) (Metraglia *et al*., 2011). It was a matter of interest to explore if the success of webcomics as a motivational instrument in teaching a foreign language could be in some way replicated in another kind of language education such as engineering graphics.

The present study aimed to understand if webcomics can be a valid motivational instrument for freshers attending an engineering graphics course, especially for students with a lower technical background. The study aimed particularly to understand if a webcomics structured in graphic novels and designed as "The adventures of Mr. Clumsy, the engineer" could be proficiently used by engineering graphics teachers as a support to keep high students' attention level during the lectures and as a support for a better explanation of the topics.

In order to satisfy these aims, this study was conducted:

- To explore if, by using webcomics in engineering graphics education, there are significant differences in the gain of motivation and attention in particular, between weaker learners, coming from a non-technical and non-scientifical high school of provenience and learners with a stronger technical and scientific background
- To find out teachers' perception of the advanteges and eventual limitations in using webcomics in an engineering graphics course
- To explore how the use of webcomics in an engineering graphics course is perceived by learners

MATERIALS AND METHODS

Design: Two classes who attended the course "engineering graphics" at the University of Brescia were used in this study. In a class (Group A), webcomics were used in the theoretical lessons, whilst in the other class (Group B) theoretical lessons were taught in the traditional way, i.e., without using webcomics. Excluding the webcomics, the same instructional material was used in both the classes. The two teachers of the classes had a shared experience of more than 6 years in teaching the same engineering graphics course at the University of Brescia. This study used a between-groups design for each class. There was one independent variable, the student's high school of provenience, with three levels: Scientific School, Technical School or Other School (non-technical and non-scientific high schools), as made by Metraglia *et al*. (2013). The dependent variables were the answers of the students to the motivational measure Course Interest Survey-CIS (see Instruments of measure).

Design of the webcomics: A graphic novel of the series "The adventures of Mr. Clumsy, the engineer" was designed using the freeware software BitStrips (www.bitstrips.com) for each of the twelve theoretical lessons of the engineering graphics course. The covered topics were: projections methods; representation and orthographic views; cuts and sections; dimensioning; parts and assemblies; measures detection from mock-ups; tolerances; roughness and surface finishing; threading; fasteners; unthreaded dismountable fasteners; elements of machines. The outline of the graphic novels was linearly repeated in every tale. In the tales, the character Mr. Clumsy faces several problems about engineering graphics. The character's approach to problems is just 'clumsy' and he usually meets mechanical technicians who have some problems with his technical drawings, because they contain mistakes or they are missing essential features. Every-time Mr. Clumsy doesn't know what to do to manage such problems, because-incredibly-he is an engineer but he doesn't know anything about engineering graphics. In some occasions, he discoveries important engineering graphics concepts by chance and in unexpected situations (Fig. 1). At the end of every tale he is given by another character an advice to fill his gap of knowledge: following the theoretical lesson that is just going to start.

Design of the message: An e-mail message was designed for the students of Group A to stimulate them to attend the theoretical lessons by referring to the use of webcomics in the engineering graphics course lectures. In the message there was a link to a webpage where the webcomics tale of the following theoretical lesson, so that students could read the webcomics prior

Fig. 1: Strips from “the adventures of Mr. Clumsy, the engineer”, tale “roughness”

Fig. 2: The teacher beginning the lesson by using the webcomics

to the lesson. The idea of sending a motivational message took inspiration by Huett *et al*. (2008). The message was as follows: “Dear Student, during this year's course of Engineering Graphics, an e-mail will be sent to you the day before each of the theoretical lessons. The idea is to introduce the topic of each lesson by a comics, created "ad hoc", whose name is "The adventures of Mr. Clumsy". Mr. Clumsy is a character that will accompany you at every theoretical lesson, that will start just with the comics. In each of the mails that will be sent to you, there will be a link to read the tale relating to the day after lesson. I hope you will take

this experiment with enthusiasm. Here is the link for the tale of the lesson of dd/mm/yyyy (date), that will concern xxx (topic)."

Procedure: The day before each of the twelve theoretical lessons, the designed e-mail message was sent to all of the students of Group A. The lessons of Group A started with the teacher reading the webcomics to the audience, projecting the strips on the screen (Fig. 2). Mr. Clumsy's adventures presented in the webcomics got translated during the lessons into practical examples of technical problems and the real consequences of Mr. Clumsy's mistakes were presented as if they were real. When the teacher showed the solutions to the mentioned technical problems, he referred again to Mr. Clumsy, concluding the explanation as it was begun, i.e., by referring to the webcomics.

Mr. Clumsy tale was recalled by the teacher on average between 2 and 5 times during each lesson. Besides being the main character of the graphics novel introducing each lecture, Mr. Clumsy was also the main reference for the common mistakes in engineering graphics. In simple words, a mistake in engineering drawing was presented by the teacher as a mistake Mr. Clumsy would do, rather than a mistake a student could do. At the end of the course-it lasted a semester-all the first-year engineering students who attended the two classes (A, webcomics and B, traditional) of the engineering graphics course were invited to participate to the study by completing a web-based survey. Participants of the Group A were also given a further questionnaire asking them about the positive and the negative aspects of the course just attended and if they had any proposal to improve it. The teacher of Group A was interviewed to gather his impression about the experience in teaching with the webcomics as a support.

Participants: One hundred and eighty students were invited. Participation was voluntary and encouraged by the chance to win one of five 16 GB pen-drives extracted by drawing lots among the participants. Participants were naïve about the purpose of the study. One hundred and sixteen students (64.4%) participated to the study. There were 69 participants of Group A (n = 69) -the class where the teaching was supported by using webcomics (40 Scientific School, 17 Technical School and 12 Other School) and 47 participants of Group B (n = 47) -the class with the traditional teaching (26 Scientific School, 5 Technical School and 16 Other School).

Instruments of measure: The web-based survey was the Course Interest Survey (CIS), an instrument to measure motivation proposed by Keller (2006a), designed to measure the four ARCS factors Attention, Relevance, Confidence and Satisfaction. The CIS had already been used in several motivational approaches, e.g., motivational mass-email messages to students before the lessons (Huett *et al*., 2008). For each participant, the four latent factors of the ARCS model were computed from the thirty-four CIS questions as instructed by Keller (2006a). This survey uses a Likert-type scale with five possible choices:

- Not true
- Slightly true
- Moderately true
- Mostly true
- Very true

Nine questions were reverse-worded by design and had to be recoded prior to the construction of the factors. The four factor scores were averaged to construct an overall motivation score as done by Huett *et al*. (2008). Cronbach's coefficient alpha was computed for each of the four factors and the overall score. A further questionnaire was submitted to the students of Group A (webcomics) at the end of the course, asking them to freely express a judgment on the course and to indicate, if any, positive and negative aspects of the course and to formulate proposals for its improvement. No specific questions about the comics were formulated. The questionnaire was anonymous. The teacher who took the course with webcomics was interviewed at the end of the course with an unstructured interview.

RESULTS

The results are presented shorting the name of the three groups of the independent variable, as made by Metraglia *et al*. (2013). Data of the students from a technical high school are labelled "Technical School". Data of students from a scientific high school are labelled "Scientific School". Data of students from non-technical and non-scientifical high school are labelled "Other School". The four measures of motivation and the overall score for each student were computed and Cronbach (1951) coefficient alpha was used for each factor to estimate the reliability. The results are found in Table 1, in comparison both with the original study of Keller (2006a) and to the more recent study of Huett *et al*. (2008). In this study the reliability was 'Good' (Cronbach, 1951), even if the values were slightly lower than Keller's originally study. Results of the CIS are reported separately for Group A (webcomics in education) and Group B (traditional teaching).

Group A (webcomics) CIS: Table 2 reports the mean and the standard deviations for each of the four factors in relation to the high school of provenience.

Table 1: CIS reliability estimates (Cronbach's α)

Scale	Current study n = 116	Huett *et al*. (2008) n = 119	Keller (2006a) n = 200
Attention	0.82	0.75	0.84
Relevance	0.77	0.80	0.84
Confidence	0.77	0.76	0.81
Satisfaction	0.79	0.85	0.88
Total scale	0.92	0.93	0.95

Table 2: Descriptive statistics for the CIS factors and composite scale-webcomics

Factors		N	Mean	S.D.
Attention	Scientific school	40	2.88	0.60
	Technical school	17	3.01	0.66
	Other	12	3.53	0.41
	Total	69	3.03	0.63
Relevance	Scientific school	40	3.43	0.51
	Technical school	17	3.75	0.50
	Other	12	3.67	0.38
	Total	69	3.55	0.50
Confidence	Scientific school	40	3.47	0.61
	Technical school	17	3.87	0.53
	Other	12	3.58	0.59
	Total	69	3.57	0.59
Satisfaction	Scientific school	40	3.37	0.60
	Technical school	17	3.59	0.48
	Other	12	3.63	0.42
	Total	69	3.47	0.55
ARCS measure	Scientific school	40	3.29	0.47
	Technical school	17	3.55	0.40
	Other	12	3.58	0.35
	Total	69	3.41	0.45

S.D.: Standard deviation

Table 3: Descriptive statistics for the CIS factors and composite scale-traditional

Factors		N	Mean	S.D.
Attention	Scientific school	26	3.00	0.59
	Technical school	5	3.00	0.45
	Other	16	3.38	0.93
	Total	47	3.13	0.73
Relevance	Scientific school	26	3.26	0.48
	Technical school	5	3.62	0.66
	Other	16	3.59	0.80
	Total	47	3.41	0.63
Confidence	Scientific school	26	3.35	0.52
	Technical school	5	3.53	0.77
	Other	16	3.49	0.60
	Total	47	3.42	0.57
Satisfaction	Scientific school	26	3.24	0.65
	Technical school	5	3.48	0.64
	Other	16	3.63	0.77
	Total	47	3.40	0.70
ARCS measure	Scientific school	26	3.21	0.49
	Technical school	5	3.41	0.54
	Other	16	3.52	0.69
	Total	47	3.34	0.58

S.D.: Standard deviation

Kolmogorov-Sminorv (K-S) Tests of Normality and Levene's Tests for Equality of Variances were computed for the three groups. No statistically significant differences were found. Therefore, normality of distribution and homogeneity of variance were assumed for all of the three groups. A one-way Analysis of Variance (ANOVA) with independent measures was conducted on these data. This revealed a significant effect of high school of provenience on Attention, F (2, 66) = 5.57, p<0.01, ω^2 = 0.12, whose size was definable medium to large effect according to Kirk (1996). There was not a significant effect of high school of provenience on Relevance, F (2, 66) = 1.35, p = 0.07, *ns*, on Confidence, F (2, 66) = 1.95, p = 0.06, *ns* and on Satisfaction, F (2, 66) = 0.91, p = 0.23, *ns*. There was a significant effect of high school of provenience on the overall ARCS, F (2, 66) = 1.27, p<0.05, ω^2 = 0.06, representing a medium effect according to Kirk (1996). Games-Howell post-hoc tests revealed that Attention was significantly higher for Other School compared to Scientific School (p<0.01) and significantly higher for Other School compared to Technical School (p<0.05). No significant differences between the three groups were found for Relevance. Confidence was significantly higher for Technical School compared to Scientific School (p<0.05), whilst no significant differences were measured for Other School compared to Scientific School and Technical School. No significant differences between the three groups were found for Satisfaction. ARCS mean was significantly higher for Scientific School compared to Technical School (p<0.05), whilst no significant differences were measured for Other School compared to Scientific and Technical School.

To resume, in the class where webcomics were used in teaching, Attention, Confidence and the overall ARCS measure were significantly affected by the high school of provenience of the freshers. Particularly, Attention was higher for students coming from Other School compared to Scientific and Technical School. Confidence was higher for students coming from Technical School compared to Scientific School. The overall ARCS measure was higher for students coming from Scientific School compared to Technical School.

Group B (traditional, no webcomics) CIS: Table 3 reports the mean and the standard deviations for each of the four factors in relation to the high school of provenience.

Kolmogorov-Sminorv (K-S) Tests of Normality and Levene's Tests for Equality of Variances were computed for the three groups. With the K-S test, no statistically significant differences were found for Attention, Relevance, Confidence and Satisfaction for the three groups. ARCS for technical school, D (5) = 0.40, p<0.01 was significantly not normal. No significant differences were found from Levene's test, so the variances were assumed equal for the three groups. A one-way Analysis of Variance (ANOVA) with independent measures was conducted on the factors A, R, C and S. There was not a significant effect of high school of provenience on Attention, F (2, 44) = 1.58, p = 0.23, *ns*, on Relevance, F (2, 44) = 1.33, p = 0.20, *ns*, on Confidence, F (2, 44) = 0.26, p = 0.68, *ns*, on Satisfaction, F (2, 44) = 1.56, p = 0.21, *ns*. A

Kruskal-Wallis test was conducted on the ARCS measure. There was not a significant effect of high school on the overall ARCS, $H(2) = 3.58$, $p = 0.17$, *ns*. Games-Howell post-hoc tests revealed that there were not significant differences between Scientific School, Technical School and Other School for A, R, C, S and ARCS.

To resume, in the class where webcomics were not used in teaching, there were no significant differences on the various scales of motivation between students from Scientific School, Technical School or Other School. The school of provenience did not affect freshers' motivation.

Group A (webcomics) teacher's opinion: The teacher of Group A indicated several benefits of his experience of teaching engineering graphics using the graphic novel "The adventures of Mr. Clumsy, the engineer" as a support. He argued that especially in the longest theoretical lessons the use of the webcomics had made the lectures "lighter" for the students and for himself as well. He reported that by introducing the lesson with a humouristic webcomics, the atmosphere got friendly and relaxing for students, that were less ashamed to make questions. According to the teacher, webcomics were actually useful for students with different backgrounds: "In engineering graphics courses students from technical schools are likely to have some experience of handling machine parts in a mechanic's workshop, whilst other students usually don't know anything about machining when at the beginning of the course.", he said, "It is really hard in teaching to refer to practical experiences shared among all the students, because they are generally very few or none. However, webcomics were a sort of "plot" to refer to, as it was a sort of shared experience". The teacher concluded the interview saying that the use of webcomics pushed him to better armonize the level of focus and details in the explanation of the topics and that he would use such webcomics in the next engineering graphics courses.

Group A (webcomics) students' opinion: Sixty students of the 69 (87.0%) of Group A (webcomics) returned the questionnaire and 18 questionnaires (30.0% of the returned questionnaires) contained one ore more comments relating to the webcomics used at lesson. Most of the comments were positive. According to three students, by using webcomics, lessons were "nice and well explained" and "stimulated the learning". Two students considered the webcomics useful to "improve the clarity of the lesson explanations". A student defined it a way to "focus the attention on the topic treated" and another "a way to show clear examples of the problems treated". Another scholar considered the webcomics "a nice idea to start the lessons" because "it helped the creation of a friendly atmoshpere". Two students appreciated the fact a teacher of an engineering college used such approach, that was "nice" and "stimulating the interest of the students". Another student suggested to use it also in the next year engineering graphics course. Also some negative judgments were registered. Two students complained that the webcomics "did not concern examples of real life situations" and that "the problems presented in the webcomics were not close to the real ones". Finally, a students observed that "the webcomics used were not so funny".

DISCUSSION

For the Course Interest Survey (CIS), the analysis of the variance showed that in the class where webcomics were used in teaching there was a statistically significant difference in means for Attention ($p<0.01$) between students from Scientific school, Technical school and other school. For Attention, post hoc tests showed that students from Other school scored higher levels compared to students from Scientific School ($p<0.01$) and students from Technical School ($p<0.05$). The effect size of Attention ($\omega^2 = 0.12$) was medium to large. In the engineering graphics course taught traditionally-without using comics-the analysis showed none significant differences between the groups for Attention. That result makes sense with the aim of the webcomics used in this experiment. "The adventures of Mr. Clumsy" was designed just to gain students' attention, to stimulate them generating questions and to maintain their interest during the theoretical lessons, according to the strategies promoted by Keller (1987b). From this study we can gather that in the engineering graphics course taught with webcomics a positive effect on motivation was measured, especially for weakers, confirming Hosler and Boomer (2011) and Salehi *et al*. (2012). Vice versa, in the engineering graphics course taught traditionally, there were no significant relationships between motivation and attitude toward engineering and technical graphics, confirming Ernst and Clark (2012). For Relevance, no statistically significant differences in means were found for the three groups in both the classes. For Confidence, students from Technical School scored a higher level compared to students from Scientific School both in the two classes and in Group A in a significant way ($p<0.05$). That results make sense with the fact the webcomics was actually not designed to improve directly student's confidence with the matter. Students from Technical School, at the end of the course, have still a self-perception of a high confidence with engineering graphics topics, because they integrated their previous knowledge. Vice versa, students from non-technical schools usually don't perceive a similar level of self-confidence, because they have less experience. The fact that such difference was significant for the class where webcomics were used could lead to a curious interpretation. It could be that an instrument simplifying engineering graphics topics could make advanced learners feel they are more confident with the matter. For Satisfaction, no statistically significant differences in means were found

for the three groups in both the classes. For the overall measure ARCS, there was a statistically significant difference in means for the Group A (webcomics) ($p<0.05$), but post hoc tests did not identify any true effect of the high school of provenience (post hoc tests have less power than planned comparison to detect true effects and the 2-tailed p were close to the limit 0.05 but above); no statistically significant differences in means were found for Group B (traditional).

The teacher's perception on the use of webcomics was very positive. Webcomics were considered by the teacher as a tool to encourage weakers to actively participate to the lessons, confirming Salehi *et al*. (2012). To approach the lesson that way it created a friendly atmosphere and stimulated students to ask questions in a number higher than usual. The teacher considered the webcomics a valid instrument to motivate students at theoretical lessons, confirming Yang (2003b) and to introduce technical examples in a light and enjoyable way. The webcomics was used as a way to create shared experiences to refer to during the lessons, so to avoid the referring to previous technical experiences that just students with a technical background generally have. The teacher expressed the intention to use the webcomics "The adventures of Mr. Clumsy, the engineer" in the next engineering graphics courses, confirming the positive perception of trainers in Salehi *et al*. (2012).

Students' comments supported the idea that using the webcomics "The adventures of Mr. Clumsy" had an important role in keeping at a high level the attention during the theoretical lessons. The idea of narrating stories in graphic novels was appreciated, confirming for engineering graphics the success in motivating weaker students to learn, as it happened for a foreign language (Zimmerman, 2010) and biology (Hosler and Boomer, 2011). However, some students argued that the problems treated in "The adventures of Mr. Clumsy, the engineer" were not close to the real life ones. The questionnaires were anonymous, but it is likeable that this kind of comments were expressed by students coming from a technical high school. In effect, such students, when beginning the engineering graphics course, usually already know some of the real problems a technician normally meets in technical drawing or in a workshop. As a consequence, they can estimate the distance between such problems and their generic representation in the webcomics. This kind of comments reflects a challenging aspect in motivating an audience composed by advanced learnes and weakers, confirming Salehi *et al*. (2012). Students from technical schools would probably be more motivated if they were taught things they have never seen before. However, most of the programme of the engineering graphics course for first-year engineering students actually replies topics they have already studied at high school. Vice vesa, students from non-technical schools usually know little or none about engineering graphics at the beginning of the course. Hence, they would be more motivated if topics were presented in a gradual way as indicated by Yang (2003a) and Hosler and Boomer (2011).

Although it would be difficult to claim that the use of webcomics was the only cause of the differences in Attention between the weaker students and the others, it seems reasonable to affirm that a webcomics structured in graphic novels designed as "The adventures of Mr. Clumsy, the engineer" can be proficiently used by engineering graphics teachers as a support to keep high students' attention level during the lessons and as a support for a better explanation of the topics.

CONCLUSION

In engineering graphics courses at colleges, first-year engineering students have different high school of provenience and different technical backgrounds. Students with a lower technical background need more motivation when attending engineering graphics lessons. This study showed that the use of webcomics structured in graphic novels in such lessons is a proficient way to better motivate such students and to arouse and keep their attention at a high level.

LIMITATIONS AND RECOMMENDATIONS

Regarding the design of the study, the main limitation was that convenience samples were used. The two classes used in this study were already built and it was not possible neither to randomize students in the two classes, nor to distribute them in similar quotes in the two classes according to their high school of provenience. The number of students from each kind of school in the two classes were very different. As a consequence, it was not possible to make a reliable comparison between the students of the webcomics class and the ones of the traditional class. In a further research, randomizing students and clustering them according to their high school of provenience would make it possible to compare them. The second limitation of the study regards the second questionnaire submitted to the students of the webcomics class. Such questionnaire asked just general impressions on the course and it did not focus on the perception of the use of comics in the course. Despite a sensitive number of students commented the course referring to the webcomics, in a further study it would be reasonable to ask specific questions about it. Finally, some webcomics were probably better designed or more useful than others to students, but no measure of the appreciation of the webcomics for each lesson was taken. In a further research, it would be reasonable to ask students to evaluate each webcomics, perhaps on a likelihood five-point Likert scale.

ACKNOWLEDGMENT

A special thank you goes to who contributed to this research. Diego Taglietti e Marco Paterlini for drawing the strips of the webcomics "Le avventure dell'ingegner

Maldestri" (The adventures of Mr. Clumsy, the engineer), giving "digital" life to the authors' scripts. Gabriele Baronio for his collaboration in teaching the traditional way in the engineering graphics course. Riccardo Adamini for making data about students' high school of provenience available. The Department of Mechanical and Industrial Engineering and the University of Brescia for hosting the research.

REFERENCES

Baillie, C. and G. Fitzgerald, 2000. Motivation and attrition in engineering students. Eur. J. Eng. Educ., 25(2): 145-155.

Contero, M., F. Naya, P. Company, J.L. Saorìn and J. Conesa, 2005. Improving visualization skills in engineering education. IEEE Comput. Graph., 25(5): 24-31.

Cronbach, L.J., 1951. Coefficient alpha and the internal structure of tests. Psychometrik, 16: 297-334.

Davis, R.S., 1997. Comics: A Multi-Dimensional Teaching Aid in Integrated-skills Classes. Retrieved from: http://www.esl-lab.com/research/comics. htm.

Dutta, P. and A. Haubold, 2007. A model for teaching engineering design. Proceedings of the 37th Frontiers in Education Conference. Milwaukee, WI, Oct. 10-13, S2J: 14-19.

Ernst, J.V. and A.C. Clark, 2012. Attitudes and motivation of students in an introductory technical graphics course: A meta-analysis study. Eng. Des. Graph. J., 76(2): 1-16.

Hosler, J. and K.B. Boomer, 2011. Are comic books an effective way to engage nonmajors in learning and appreciating science? CBE-Life Sci. Educ., 10(3): 309-317.

Huett, J.B., K.E. Kalinowski, L. Moller and K.C. Huett, 2008. Improving the motivation and retention of online students through the use of ARCS-based E-mails. Am. J. Distance Educ., 22: 159-176.

Kakalios, J., 2002. Adding pow! To your physics class with comic-book lessons. Curriculum Rev., 42.2: 14-15.

Keller, J.M., 1987a. Development and use of the ARCS model of motivational design. J. Instruct. Dev., 10(3): 2-10.

Keller, J.M., 1987b. Strategies for stimulating the motivation to learn. Perform. Instruct., 26(8): 1-7.

Keller, J.M., 1987c. The systematic process of motivational design. Perform. Instruct., 26(9): 1-8.

Keller, J.M., 2006a. Development of two measures of learner motivation. Florida State University, Tallahassee, United States.

Keller, J.M., 2006b. What is Motivational Design? Retrieved from: http://www.arcsmodel.com/#!motivational-design/c2275.

Keller, J.M. and K. Suzuki, 1988. Use of the ARCS Motivation Model in Courseware Design. In: Jonassen, D.H. (Ed.), Instructional Designs for Microcomputer Courseware. Lawrence Erlbaum, Hillsdale, NJ.

Kirk, R., 1996. Practical significance: A concept whose time has come. Educ. Psychol. Meas., 56(5): 746-759.

McLuhan, M. and L.H. Lapham, 1994. Understanding Media. The Extensions of Man. Reprint Edn., MIT Press, Cambridge, Mass.

Metraglia, R., G. Baronio and V. Villa, 2011. Learning levels in technical drawing education: Proposal for an assessment grid based on the European Qualifications Framework (EQF). Proceedings of the 18th International Conference on Engineering Design. Lingby/Copenaghen, Denmark, Aug. 15-19, 8: 161-172.

Metraglia, R., G. Baronio, V. Villa and R. Adamini, 2013. Development of a self-assessment questionnaire for basic technical drawing skills: A preliminary study. Proc. Soc. Behav. Sci., 106: 848-859.

Norton, B., 2003. The motivating power of comic books: Insights from archie comic readers. Read. Teach., 57(2): 140-147.

Retalis, S., 2008. State of the Art Comics in Education. Using Web Comics in Education. Retrieved from: http://www.educomics.org/material/deliverables/Deliverable1_StateoftheArt.pdf.

Salas-Morera, L., M.A. Cejas-Molina, J.L. Olivares-Olmedilla, M.S. Climent-Bellido, J.A. Leva-Ramírez and P. Martínez-Jiménez, 2013. Improving engineering skills in high school students: A partnership between university and K-12 teachers. Int. J. Technol. Des. Ed., 23(4): 903-920.

Salehi, H., M.M. Yunus and M.A. Embi, 2012. Effects of using digital comics to improve ESL writing. Res. J. Appl. Sci. Eng. Technol., 4(18): 3462-3469.

Tatalovic, M., 2009. Science comics as tools for science education and communication: A brief, exploratory study. J. Sci. Commun., 8(4): 1-17.

Versaci, R., 2001. How comic books can change the way our students see literature: One teacher's perspective. Engl. J., 91(2): 61-67.

Williams, N., 1995. The comic book as course book: Why and how. Proceeding of the Annual Meeting of the Teachers of English to Speakers of Other Languages. Long Beach, CA.

Yang, G., 2003a. History of Comics in Education. Comics in Education. Retrieved from: http://www.geneyang.com/comicsedu/history.html.

Yang, G., 2003b. Strenghts of Comics in Education. Comics in Education. Retrieved from: http://www.geneyang.com/comicsedu/strengths.html.

Zimmerman, B., 2010. Using Digital Comics for Language Learning. eLearn Magazine. Retrieved from: http://elearnmag.acm.org/archive.cfm?aid = 1710033.