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SUBTITLING SCIENCE
An efficient task to learn content and language

FRANCESCA BIANCHI
UNIVERSITY OF SALENTO

Abstract – The current study aims to investigate the potential of subtitling (i.e. creating subtitles) as a means to teach/learn specialised content and a foreign language simultaneously and attempts to measure its impact by comparing creating subtitles to watching subtitled video. This was operationalized in the following research questions: Does creating subtitles help the acquisition of scientific content? Does creating subtitles help the acquisition of scientific vocabulary? How does creating subtitles compare to watching subtitled video? And, does creating subtitles increase the student's interest in science? In order to answer these research questions, two experiments were carried out: a group of students created English and Italian subtitles for a set of short videos in English about chemistry and physics. Subsequently, some of the videos were shown to a different group of students, accompanied by English and/or Italian subtitles. All the students were tested on the contents and language in the videos. The students who created subtitles were assessed about seven days after completion of the work, while the students who watched ready-made subtitles were tested immediately after watching the video. The study showed that both activities (watching ready-made subtitles and creating subtitles) helped content understanding and language memorization. It also suggested that creating subtitles is probably a much more effective activity for language and content acquisition than watching subtitles. Finally, it showed that, though both activities increased students' interest in science, creating subtitles increased the students' interest to a higher extent.

Keywords: subtitling; subtitles; content learning; vocabulary learning; science.

1. Introduction

Videos have long been used in class by teachers of various disciplines and at all levels of schooling (see for example Alves 2014 for geography, Mathews, Fornaciari, Rubens 2012 for management, and Efthimiou, Llewellyn 2004 for science) and are a type of learning material that is much appreciated by students (Kluzer, Ferrari, Centeno 2011). It is their multimodal nature – characterized by the co-presence of images, sound and dialogues, and frequently also by some type of narrative structure – that makes excellent tools for teaching and learning of all multimedia products, including documentaries, film products and videos in general (Berk 2009; Mathews, Fornaciari, Rubens 2012). Indeed, the co-presence and constant interaction of several different semiotic levels stimulate the human brain more than monomodal texts and activate different types of intelligence, including the linguistic, spatial, musical, and emotional ones (Berk 2009). Furthermore, videos have proven useful in stimulating student's attention, imagination, and critical debate, not to mention the fact that their contents have a long-lasting impact on our memory (Mathews, Fornaciari, Rubens 2012).

Thanks to modern technology, videos can easily be enriched with subtitles. Empirical studies on the impact of subtitles on learning have shown that subtitles (either intralingual or interlingual) enhance the acquisition and development of L2 vocabulary (see for example Neuman, Koskinen 1992; Danan 1992; Baltova 1999; Koolstra, Bentjes 1999; Bianchi, Ciabattoni 2007, Zarei 2009, Fazilatfar, Ghorbani, Samavarki 2011;

Hayati, Mohmedi 2011; Montero Perez, Van Den Noortgate, Desmet 2013), listening comprehension skills (see for example Markham 1989; Montero Perez, Van Den Noortgate, Desmet 2013), content memorization (see for example Markham 1989; Garza 1991; Danan 1992; Neuman, Koskinen 1992; Baltova 1999; Koolstra, Bentjes 1999), and also motivation (see for example Vanderplank 1988; Čepon 2011).

Audiovisual material (with or without subtitles) has also been used in content-based instruction in a foreign language (see for example Kumar, Scarola 2006; Chapple, Curtis 2000; Mahlasela 2012).

Recently, some attention has also been paid to the process of subtitling and its possible pedagogical benefits in language teaching/learning, though the experimental studies are few. Diaz-Cintas (2008) suggests subtitling as a pedagogically beneficial practice for learning vocabulary and socio-cultural awareness. Williams and Thorne (2000) describe a pilot study in which they required language students to subtitle TV programmes of their choice. These authors report considerable improvement in students' listening skills, increased vocabulary, improved punctuation skills, the students' ability to repeat long passages of speech, word for word, and greater awareness of their language competence. Talavan (2010) reports an experiment aimed at establishing the role of subtitling tasks in the development of comprehension skills. An experimental group watched a videoclip with intralingual subtitles (step 1), produced interlingual subtitles of the previously watched video (step 2), and finally watched a second video with intralingual subtitles (step 3); at the end of steps 1 and 3, the students were given a comprehension test requiring an oral summary of the video contents. A control group worked on the same videos, but was not engaged in the subtitling activity. Comparison between the experimental and control data at the comprehension test showed that the experimental students achieved significantly higher levels of comprehension. Finally, Beseghi (2013) engaged language translation students in subtitling episodes of their favourite TV series and noticed improvements in foreign language acquisition, and in motivation, as well as in translation skills in general. None of these experimental studies provides definitive quantitative evidence of the role of subtitling in language learning or of its superiority to reading ready-made subtitles. However, they all suggest that such an impact is very likely.

Indeed, as Williams and Thorne (2000, p. 219-220) point out, subtitling obliges the student to:

- Listen attentively, recognise and fully absorb the content of the programme […]
- Read/view the screen for visual clues which place the language into meaningful context […]
- Translate, or more precisely, interpret all of the above, in an effective and natural manner, into the target language, using words, expressions and a style which accurately represents the original […]
- With regard to the technical considerations imposed by the medium, the subtitler has to edit the content in such a way that the original meaning will remain intact, but will allow for comfortable reading by the audience […]
- Consider the register of the language of the subtitles […]

Such premises lead us to hypothesize that the creation of subtitles could be adopted as an interesting task in a range of pedagogical scenarios focussing on the acquisition of specialised content and specialised language, including for example content-based instruction in a foreign language or Content-Language Integrated Learning (CLIL) scenarios.

In the wake of the experiments reported above, the current study aims to investigate the potential of subtitling as a means to teach/learn specialised content and a foreign language simultaneously and attempts to measure its impact by comparing creating subtitles to watching subtitled video. This was operationalized in the following research questions: Does creating subtitles help the acquisition of scientific content? Does creating subtitles help the acquisition of scientific vocabulary? How does creating subtitles compare to watching subtitled video? And, does creating subtitles increase the student's interest in science? In order to answer these questions, two experiments were carried out: a group of students, hereafter called 'subtitling students', created English and Italian subtitles for a set of short videos in English about chemistry and physics. Subsequently, some of the videos, accompanied by English and/or Italian subtitles, were shown to a different group of students, hereafter called 'watching students'. All the students were tested on the contents and language in the videos. It must be stressed from the outset that the gathering of the data was performed within ordinary teaching activities and was thus guided by opportunity and teaching needs. This means that the experimental framework is far from perfect. However, as we shall see, comparison between the performances of the two groups may still provide some insight into the potential of subtitling over ready-made subtitles.

The following paragraphs describe the two experiments, their materials and participants (Section 2), discuss and compare the students' results for the content and language tests (Section 3), and draw some tentative conclusions about the potential of subtitling in content and language learning (Section 4).

2. The experiment, its participants, materials and methods

The current experiment consisted in the following steps: 1. a group of students created subtitles for videos dealing with science (subtitling students); 2. after about a week, the subtitling students were asked to do a questionnaire aiming to assess the acquisition of technical vocabulary and contents of the video(s) they subtitled; 3. some of the subtitled videos were shown to students who had not taken part in the subtitling activities (watching students) and these students were administered content and vocabulary questionnaires; 4. the results of the subtitling students were compared to those of the watching students. The following paragraphs describe the experiment in greater detail.

2.1 The subtitling students

The subtitling students included 24 students specialising in foreign languages and translation, in their first year of a Master's degree programme. The subtitling students were asked to create English and Italian subtitles for 12 short science videos in English. The videos, dealing with chemistry or physics, were selected by the authors from among those available on the VEGA and GEOSET websites – two portals specifically created by Nobel Laureate in Chemistry Sir Harry Kroto, for teaching and popularization purposes.[1] Each video was approximately 7 minutes in length. Each student worked on one video; however more than one student worked – individually and separately – on the same video.

[1] For further details about the Vega and the Geoset projects, and to access their video databases, see: vega.org.uk; and www.geoset.info.

The subtitling task – organized in the form of a project work – was an integral part of the students' curricular exam in audiovisual translation. The project work commenced after a 25-hour training in the theory and practice of subtitling; the training included an introduction to subtitling strategies and some frequent issues in audiovisual translation, as well as hands-on use of VisualSubSync,[2] a semi-professional subtitling software tool.

In order to create the subtitles, the students worked individually and began by transcribing the original dialogues. All the transcripts were checked by the author, who was also the teacher in charge of the audiovisual translation module. When a linguistic inaccuracy was spotted in the student's transcript, the researcher did not correct it, but rather highlighted the mistake and gave the student suggestions for self-correction. Typical mistakes included incorrect subject-verb agreement, verb tense, prepositions, determiners, and wrong spelling. In these cases, the student was simply advised to check the grammatical correctness and logic of the sentence and was invited to look the words up in a dictionary if necessary. Other typical mistakes regarded pieces of text including technical terms, geographical terms, such as names of rivers or small towns, or names of (usually famous) people. In these cases, the student was invited to identify the part of speech of the incorrect element, guess its semantic domain, search the Internet for texts about the given topic, and scan the texts carefully to find possible candidates.

At completion of the transcription, and taking advantage of VisualSubSync, the students created the English subtitles by adapting, timing and spotting the English text to the video. Subsequently, in a separate file, they produced the Italian subtitles. The students created the Italian subtitles by first translating the English ones, and then adapting them to the video; they also fine-tuned or modified timing and spotting, if necessary. The students were left to their own devices during the translation process, after being instructed to resort to comparable documents from the web rather than to dictionaries when looking for translation equivalents. Thus, for almost all the subtitling students, web searches and extra readings about the topic of the video became two essential parts of the transcription and translation processes.

Finally, the students burned the subtitles into the original video,[3] producing two subtitled versions of it, and sent their final products to the author for marking. Marking was a joint effort between the author, who judged the linguistic and subtitling aspects, and a physicist, who judged the scientific ones.

About seven days after completion of the project work, the subtitling students were administered specifically designed questionnaires in order to assess their acquisition of the scientific content and language in the videos. The questionnaires, the rating scheme and the data collected are described in Section 2.3.

2.2 The watching students

The watching group included 18 undergraduate students specialising in foreign languages and translation, at the end of their third and last year of studies of a bachelor's degree. The watching students took part in the experiment during the last few classes of a module about liaison interpreting. For these students, watching the subtitled videos was not a core

[2] This tool can be downloaded in its original version at http://www.visualsubsync.org/ or in an adapted version for the Italian language at http://sourceforge.net/projects/vss-itasa/.

[3] Burning subtitles into a video file can be achieved using a range of software programs. An easy-to-use, and free program is VLC.

part of their training or exam, and the students were not obliged to attend. Consequently, those who attended did so because they enjoyed the tasks.

The watching students were shown a selection of the science videos subtitled by the subtitling students.

In four separate sessions of one hour each, the watching students were tested under three different conditions and watched: one video with English subtitles only (Condition 1); two videos with Italian subtitles only (Condition 2); one video with English subtitles followed by the same video with Italian subtitles (Condition 3). Under Conditions 1 and 2, each video was shown three times; under Condition 3 the video was shown twice with English subtitles and twice with Italian subtitles. The watching students were given the same questionnaires used with the subtitling students. Under Conditions 1 and 2 the questionnaire was given immediately after the three viewings; under Condition 3, the questionnaire was administered twice – immediately after the viewings with English subtitles, and then again after the viewings with Italian subtitles. The questionnaires, the rating scheme and the data collected are described in Section 2.3.

With the watching students, the questionnaires were used to assess short-term acquisition of the scientific content and language in the videos.

2.3 The questionnaires

Since the videos subtitled by the subtitling students were many, and all different, several questionnaires were prepared, each one targeting a different video. In each questionnaire, the items differed in content and number, depending on the video's contents and length; however, the structure and logic was the same in all questionnaires. Furthermore, since all the participants were Italian native speakers, it was decided to ask about the content and general questions in Italian and to let the participants reply in the same language. As shown in the Appendix, the questionnaires were divided into three sections.

The first section included open-ended questions about the scientific contents of the video. The participants were invited to provide an answer in Italian. Depending on the questions, the correct/expected answers included: a single word or figure (e.g.: Q: How many atoms are there in C60? A: 60; Q: What is the shape of a C60 molecule? A: [The shape of a] Football.); a list of things (e.g.: Q: What are the three naturally occurring forms of pure carbon we know of? A: Diamond, graphite, and amorphous carbon); or a brief sentence/description (e.g.: Q: What is the difference between graphene and graphite? A: Graphite is made of graphene layers (or any alternative sentence to the same effect). For each question/answer in this section, the participants were required to declare their prior knowledge by choosing from among four alternatives:

1 – I didn't know anything about this topic.
2 – I knew something about the topic, but learnt this particular content through the project work/video.
3 – I knew this content, and the project work/video helped me refresh my memory.
4 – I knew everything about the topic; I could have answered this question even without the project work/video.

The four answers create a Likert scale in which answers 1 and 2 represent different degrees of ignorance about the item, and answers 3 and 4 different degrees of knowledge of the item.

The second section includes vocabulary items in Italian or English, to translate into English or Italian, respectively. In this task, it was decided to focus on words or phrases without lexical context, in order to prevent inferencing. After all, the larger context was

the video itself and it was known to the participants. Like in the content section, the participants were required to declare their prior knowledge for each translation item. In this section, the previous-knowledge self-rating system included five alternatives:

1 – I had never heard this word or its translation before.
2 – I didn't know the English word, but knew the Italian one.
3 – I didn't know the English word or the Italian one, but context helped guessing.
4 – I didn't know the English word, but it was clear from the context; and I knew the Italian one.
5 – I already knew the English and Italian words.

Answers 1 and 3 imply no previous knowledge; answers 2 and 4 imply previous knowledge of one item in the tested language pair; answer 5 implies knowledge of both items of the language pair.

Finally, the third section comprises two questions regarding: a) the student's interest in science; b) increase in the student's interest after the experiment. The participants were asked to declare their interest by selecting from four options:

1 – no.
2 – very little.
3 – quite.
4 – very much.

The four answers create a Likert scale in which answers 1 and 2 represent different degrees of dislike, and answers 3 and 4 different degrees of appreciation.

The tables below provide a summary of the number of content and language answers (C items, and L items, respectively) that were collected and analysed, with reference to the subtitling students (Table 1), and the watching students (Table 2).

Student	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	**Total**
C items	6	6	6	9	9	9	9	9	9	14	14	14	9	9	6	6	6	8	7	5	5	9	9	9	202
L items	9	9	9	9	9	9	11	9	9	9	9	9	11	11	14	14	14	6	18	10	10	8	14	14	254

Table 1
Summary of the subtitling students' data.

Condition	**Video**	**N. of Students**	**C items**	**L items**
1 (English subs)	A	9	81	126
2 (Italian subs)	B	17	119	306
2 (Italian subs)	C	18	162	162
Total		35	281	468
3 (partial – English subs)	D	9	126	81
3 (complete – Italian subs)	D			

Table 2
Summary of the watching students' data.

When assessing the answers, the researchers distinguished among incorrect answers (scoring 0), correct answers (scoring 1), and partially correct answers (scoring 0.5). A partially correct answer could be, for example, an incomplete list in the content section, or a misspelt but otherwise correct word in the language section.

Regarding language items, since the previous-knowledge rating system included qualitative categories, the student answers were further elaborated as follows:

- items marked with 1 and 3 – implying no previous knowledge – were given 0 points;
- items marked with 2 and 4 – implying previous knowledge of one part of the language pair tested – were given 0.5 points;
- items marked with 5 – implying knowledge of both items of the language pair – were given 1 point.

This made it possible to calculate the average previous knowledge of each student/group, compare this value to the student's average score, and calculate knowledge gain.

The following section summarises and compares the results of the students.

3. Results and discussion

The current section analyses the results of subtitling students and watching students on the content items, the language items, and the 'love for science' items.

For each group of students and for each questionnaire section, the analyses addressed the following questions:

- Did the students learn from the activity?
- To what extent were the questions/items known to the students?
- Is there a direct relation between declared previous knowledge and correctness of the answers?

Comparisons between the two groups will also be attempted, although the uncontrolled variables are many. In order to minimize the impact of individual video or student specificities, the data of watching students will be compared to the average results of the students who subtitled the given video, as well as to the average results of the entire subtitling group.

3.1 Content results: subtitling students

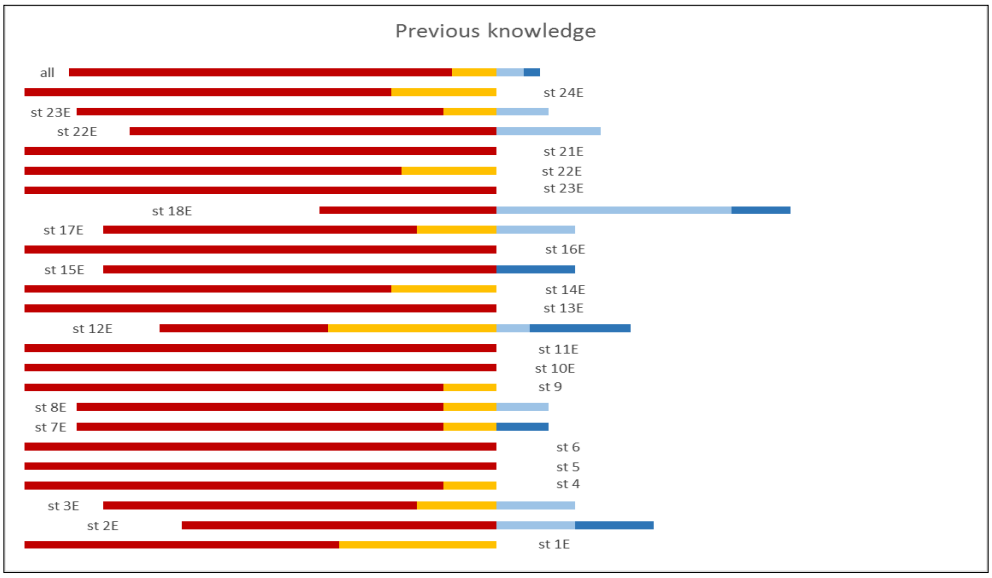
The results of the subtitling students at the questions about the contents of the videos are summarized in Table 3.

The first column shows the student identity number; the second column reports the name of the video each student worked on (the videos marked as A, B, C, and D were the ones used in the watching situations); the third column shows the average content results; the Previous Knowledge – Distribution columns report the percentage of items corresponding to each value in the previous-knowledge Likert scale; and the remaining columns report the percentage of correct, partially correct, and incorrect answers. Average scores are given to the second decimal place, while distribution percentages are rounded to the first decimal place.

Student	Video	Average score	Previous Knowledge – Distribution (%)				Score – Distribution (%)		
			1	2	3	4	1.00	0.50	0
1E	Buckyball 2	0.75	66.7	33.3	0	0	66.8	16.6	16.6
2E	Buckyball 2	0.75	66.7	0	16.7	16.7	50.0	50.0	0
3E	Buckyball 2	0.92	66.7	16.7	16.7	0	93.4	16.6	0
4E	Buckyball 1	0.67	88.9	11.1	0	0	66.6	0	33.4
5E	Buckyball 1	0.56	100	0	0	0	55.6	0	44.4
6E	Buckyball 1	0.89	10	0	0	0	88.9	0	11.1
7E	C60-nanotubes	0.89	77.8	11.1	0	11.1	88.9	0	11.1
8E	Giant Fullerenes – Video C	0.89	77.8	11.1	11.1	0	77.8	0	22.2
9E	Giant Fullerenes – Video C	0.94	88.9	11.1	0	0	88.9	11.1	0
10E	Graphene 1 – Video D	0.57	100	0	0	0	50.0	14.2	35.8
11E	Graphene 1 – Video D	0.50	100	0	0	0	42.9	14.2	42.9
12E	Graphene 1 – Video D	0.75	35.7	35.7	7.1	21.4	64.4	21.4	14.2
13E	Graphene 2	0.83	100	0	0	0	77.8	11.1	11.1
14E	Graphene 2	0.83	77.8	22.2	0	0	77.8	11.1	11.1
15E	Solar Cell	0.83	83.3	0	0	16.7	66.7	33.3	0
16E	Solar Cell	0.50	100	0	0	0	33.4	33.2	33.4
17E	Solar Cell	0.75	66.7	16.7	16.7	0	66.7	16.6	16.7
18E	Piezoelectricity	0.75	37.5	0	50.0	12.5	75.0	0	25.0
19E	Potato Battery – Video B	0.71	100	0	0	0	71.4	0	28.6
20E	Soldering	0.80	80.0	20.0	0	0	60.0	40.0	0
21E	Soldering	0.40	100	0	0	0	40.0	0	60.0
22E	Seawater Battery	0.72	77.8	0	22.2	0	66.7	11.1	22.2
23E	Wavepower –Video A	0.83	77.8	11.1	11.1	0	66.7	33.3	0
24E	Wavepower –Video A	1.00	77.8	22.2	0	0	100	0	0
Group average		0.75	81.2	9.4	5.9	3.5	67.8	13.9	18.3

Table 3
Subtitling students: average results for the content questions.

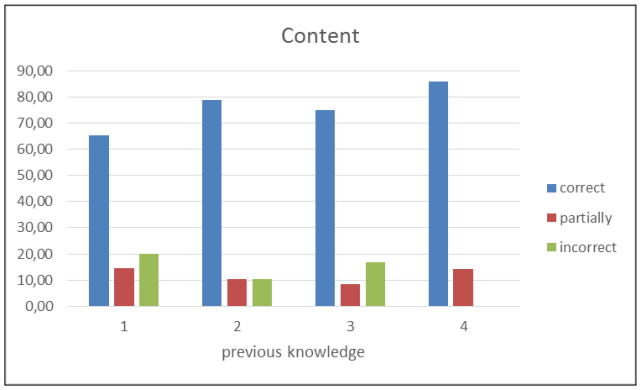
The previous knowledge rates attributed to individual items show that the contents of the videos were largely unknown to the subtitling students. This is represented in Graph 1. The top line in the graph refers to the subtitling students as a group. Maroon and yellow lines correspond to rates 1 and 2 respectively, while light blue and dark blue lines correspond to rates 3 and 4, respectively.



Graph 1
Subtitling students: previous knowledge.

Only 9.4% of the items were known to the subtitling students as a group. Despite this, the student's results were rather good, with 67.8% totally correct answers, 13.9% partially correct answers, and only 18.3% incorrect answers.

Interestingly, the only student who worked on a largely known topic (Student 18E) achieved a final average score identical to the group average score (0.75). Indeed, an analysis of the distribution of correct, partially correct and incorrect answers with respect to previous knowledge (Graph 2) confirms that correct answers were not a consequence of previous knowledge.



Graph 2
Subtitling students: distribution of correct, partially correct and incorrect answers with respect to previous knowledge.

In fact, all the four previous-knowledge-rating values show similar distributions of correct, incorrect and partially correct answers. As many as 65% of the totally unknown items were answered correctly, while 14.6% were partially correct. Similarly, 79% of the items the students marked as 2 ("I knew something about the topic, but learnt this particular content through the project work/video") were answered correctly, and 10% were at least partially correct. The items the students marked as 3 ("I knew this content, and the project work/video helped me refresh my memory) were answered correctly in 75% of cases, and partially correctly in 8% of cases. Finally, as expected, the items which were already well known to the students were answered correctly (85.7%), or partially correctly (14.3%).

Let us now briefly consider only the four videos that were subsequently used in the watching situations.

Table 4 summarises the content data collected in the subtitling situation for these four videos. The first column indicates the video; the second shows the student(s) who worked on each video (considered individually and as a 'group'); the third column reports the average results for the content questions; the following four columns illustrate the distribution of previous knowledge across the content items (indicated as a percentage of the total number of content items); finally, the last three columns report the percentage of correct, partially correct, and incorrect answers (respectively indicated by heading 1.00, 0.50, and 0.00).

Video	Student	Average score	Previous Knowledge – Distribution (%)				Score – Distribution (%)		
			1	2	3	4	1.00	0.50	0.00
A	23	0.83	77.8	11.1	11.1	0	66.7	33.3	0
	24	1.00	77.8	22.2	0	0	100	0	0
	both	0.92	77.8	16.6	5.6	0	83.3	16.7	0
B	19	0.71	100	0	0	0	71.4	0	28.6
C	8	0.89	77.8	11.1	11.1	0	77.8	22.2	0
	9	0.94	88.9	11.1	0	0	88.9	11.1	0
	both	0.92	83.3	11.1	5.6	0	83.3	16.7	0
D	10	0.57	100	0	0	0	50.0	14.3	35.7
	11	0.50	100	0	0	0	42.9	14.3	42.9
	12	0.75	35.7	35.7	7.1	21.4	64.3	21.4	14.3
	all three	0.61	78.6	11.9	2.4	7.1	52.4	16.7	31.0

Table 4
Subtitling students and videos A, B, C, and D: average results for the content questions.

The data in Table 4 suggest that videos A, B, and C were in keeping with the other videos in terms of difficulty. At the same time, the students who worked on these videos can be considered levelled with the others in terms of general previous knowledge of the video contents. Video D was probably slightly more difficult than the others, despite the fact that, as we shall see in Table 7, the contents were conveyed by known language.

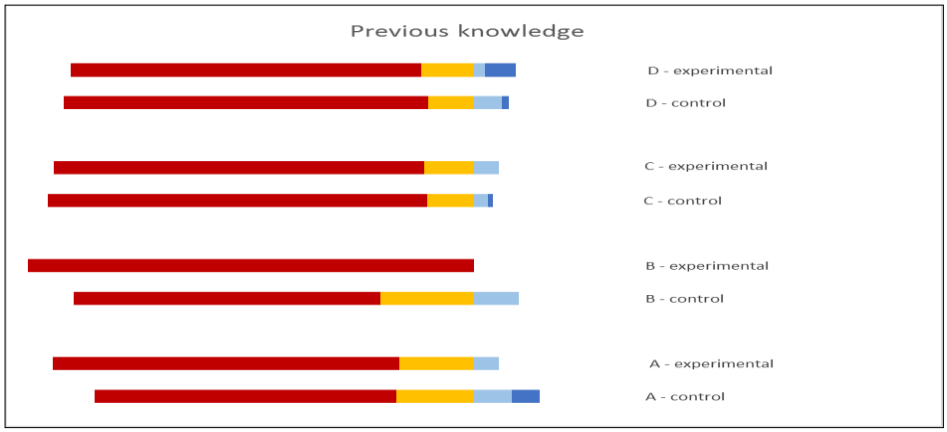
3.2 Content results: watching students

As explained in Section 2.3, only four of the videos subtitled by subtitling students were tested with watching students. However, different videos were tested under different conditions. Video A was tested with English subtitles (Condition 1). Videos B and C were tested with Italian subtitles (Condition 2). Finally, Video D was tested with two viewings with English subtitles followed by two viewings with Italian subtitles (Condition 3). Each of these conditions was expected to yield positive results for content acquisition. Condition 3 is in theory the one that is closest to the subtitling condition. Table 5 summarises the content data collected in the watching scenarios.

Condition	Average	Previous knowledge - Distribution (%)				Score – Distribution (%)		
		1	2	3	4	1.00	0.50	0.00
1 (English subs) - A	0.74	67.9	17.3	8.6	6.2	65.4	17.3	17.3
2 (Italian subs) - B	0.58	68.9	21.0	10.1	0.0	49.5	16.0	34.5
2 (Italian subs) - C	0.68	85.2	10.5	3.1	1.2	57.4	21.0	21.6
3 (partial) - D	0.44	81.7	10.3	6.3	1.6	39.7	7.9	52.4
3 (complete) - D	0.56					51.6	9.5	38.9

Table 5
Watching students: average results for the content questions.

As illustrated in Graph 3 plotting previous-knowledge ratings, the contents of the four videos were generally unknown to the watching students, and, despite local differences, overall the watching student ratings can be considered similar to those of the subtitling students.



Graph 3
Videos A, B, C, and D: content questions previous knowledge
of watching vs. subtitling students.

Let us now discuss the students' results in each watching condition, and compare them to the subtitling results. Since the number of subtitling students working on videos A, B, C, or D is limited, the watching data for each video/condition will be compared to the subtitling results yielded for that video, but also to the average results of the entire subtitling group.

3.2.1 Condition 1 – English subtitles

Nine watching students watched Video A three times, with English subtitles. The data collected in this condition (Table 5) show that this video and its English subtitles aided content understanding. In fact, the average percentage of correct answers equals 65.4%, despite the presence of 85.2% of unknown items. However, simply watching the video with subtitles lead to lower scores for the content questions, compared to creating the subtitles. In fact, the watching students' average score for this video (0.74) is just slightly lower than the average score of the subtitling group (0.75; see Table 3), and much lower (-0.18) than the average score of the subtitling students who worked on the same video (0.92; see Table 4), despite the watching students' higher preliminary knowledge (14.8% vs. 9.5% vs. 5.6% for the watching students, the entire subtitling group, and the subtitling students who worked on Video A, respectively).

3.2.2 Condition 2 – Italian subtitles

Condition two was tested on two videos: Video B, and Video C. Let us consider them separately, and compare data in Table 5 to data in Tables 3 and 4.

Video B was watched three times by 18 students, with Italian subtitles. The video and its subtitles aided content understanding, with an average percentage of correct answers equal to 49.5%, despite the fact that 89.9% of the items were unknown. However, simply watching the video with subtitles led to lower scores for the content questions, compared to creating the subtitles. In fact, the watching students' average score for this video (0.58) is much lower than the average score of the subtitling group (0.75; see Table 3), and of the average score of the subtitling student who worked on this video (0.71; see Table 4), despite the similar or higher preliminary knowledge of the first group (10% vs. 9.5% vs. 0% for the watching students, the entire subtitling group, and the subtitling

student who worked on Video A, respectively).

Video C was watched three times by 17 students, with Italian subtitles. The watching data show an average percentage of correct answers equal to 57.4%, even though as many as 95.7% of the items were unknown to the students. Once again, the watching students achieved lower scores for the content questions, compared to the subtitling students. In fact, the watching students' average score for this video (0.68) is lower than the average score of the subtitling group (0.75; see Table 3), and much lower than the average score of the subtitling students who worked on this video (0.92; see Table 4).

3.2.2 Condition 3 – English subtitles followed by Italian subtitles

Nine watching students watched Video D with English subtitles and, immediately afterwards, with Italian subtitles. The questionnaire was also given twice.

Interestingly enough, even though this video proved to be a difficult one – as we noticed in section 3.1 – some content acquisition was achieved by the watching students even at the end of the second viewing (with English subtitles only). In fact, with an average of known items as low as 8.2%, the average percentage of correct answers equals 39.7%.

At the end of their fourth and last viewing (twice with English subtitles and twice with Italian ones), the watching students provided 51.6% totally correct answers and 9.5% partially correct answers, with an average score of 0.56 (see Table 5). However, it is plausible to believe that these results do not depend exclusively on the two extra viewings and the presence of Italian subtitles, but also on the fact that the students had already seen the questionnaire and knew what to focus on while watching.

Despite this, the watching results are slightly lower than those of the subtitling students who worked on the same video (52.4% totally correct answers, 16.7% partially correct answers, and an average score of 0.61; see Table 4), and much lower than the results of the entire subtitling group (67% correct answers, 13.9% partially correct answers, and an average score of 0.75; see Table 3).

3.3 Language results: subtitling students

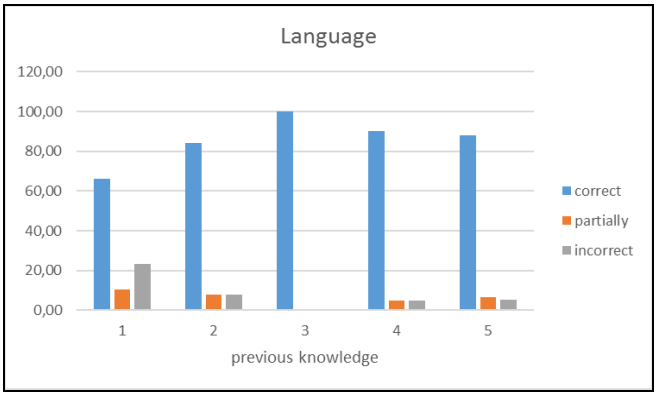
The results of the subtitling students for the questions about the language in the videos are summarized in Table 6. The first column shows the student identity number; the second column reports the name of the video each student worked on (the videos marked as A, B, C, and D were the ones used in the watching situations); the third column shows the language average results; the fourth column reports the average previous knowledge (see Section 2.3); the fifth column shows knowledge gain, i.e. the difference between the two previous scores. All percentages are given to the second decimal place.

As table 6 illustrates, the students achieved very high results for the language questions, with an average score of 0.86. Furthermore, with an average previous knowledge of 0.53, their knowledge gain amounts to an average of 0.33.

Student	Video	Average score	Average previous knowledge	Knowledge gain
1E	Buckyball 2	0.78	0.72	+0.06
2E	Buckyball 2	0.94	0.56	+0.38
3E	Buckyball 2	1.00	0.28	+0.72
4E	Buckyball 1	0.78	0.67	+0.11
5E	Buckyball 1	0.72	0.61	+0.11
6E	Buckyball 1	1.00	0.77	+0.23
7E	C60-nanotubes	0.95	0.36	+0.59
8E	Giant Fullerenes–Video C	0.78	0.61	+0.17
9E	Giant Fullerenes–Video C	0.89	0.50	+0.39
10E	Graphene 1 – Video D	0.89	0.89	0
11E	Graphene 1 – Video D	0.89	0.78	+0.11
12E	Graphene 1 – Video D	1.00	0.78	+0.22
13E	Graphene 2	0.91	0.50	+0.41
14E	Graphene 2	1.00	0.59	+0.41
15E	Solar Cell	0.86	0.36	+0.50
16E	Solar Cell	0.64	0.21	+0.43
17E	Solar Cell	0.89	0.46	+0.43
18E	Piezoelectricity	0.92	0.75	+0.17
19E	Potato Battery – Video B	0.97	0.61	+0.36
20E	Soldering	0.80	0.45	+0.35
21E	Soldering	0.65	0.00	+0.65
22E	Seawater Battery	1.00	0.69	+0.31
23E	Wavepower –Video A	0.75	0.64	+0.11
24E	Wavepower –Video A	0.79	0.36	+0.43
Group average		0.86	0.53	+0.33

Table 6
Subtitling students: average results for the language questions.

As average previous knowledge scores show, differently from what happened with content, some – if not many – of the language items tested were known to the subtitling students before they started working on the video. However, an analysis of the distribution of correct, partially correct and incorrect answers with respect to previous knowledge (Graph 4) confirms that correct answers were not a consequence of previous knowledge.



Graph 4
Subtitling students: distribution of correct, partially correct and incorrect answers with respect to previous knowledge.

Indeed, all the five previous-knowledge-rating values show similar distributions of correct, incorrect and partially correct answers. Furthermore, as Table 6 shows, there were some remarkable cases of students achieving high or very high learning scores despite low or very low previous knowledge (3E; 7E; 13E; 14E; 15E; 16E; 21E; 24E).

As we did for the content items, let us now briefly consider only the four videos that were subsequently used in the watching situations. Table 7 summarises the language data collected in the subtitling experiment for these four videos.

Video	Student	Average score	Average previous knowledge	Knowledge gain
A	23	0.75	0.64	+ 0.11
	24	0.79	0.36	+ 0.43
	both	0.77	0.50	+ 0.27
B	19	0.97	0.61	+ 0.36
C	8	0.78	0.61	+ 0.17
	9	0.89	0.50	+ 0.39
	both	0.83	0.56	+ 0.27
D	10	0.89	0.89	+ 0.00
	11	0.89	0.78	+ 0.11
	12	1.00	0.78	+ 0.22
	All three	0.93	0.82	+ 0.11

Table 7
Subtitling students and videos A, B, C, and D: average results for the language questions.

The data in Table 7 suggest that videos A, B, and C were in keeping with the other videos in terms of language novelty. At the same time, the students who worked on these videos can be considered levelled with the other subtitling students in terms of general knowledge of the video contents. Video D, on the other hand, included a higher number of well-known linguistic items.

3.4 Language results: watching students

Table 8 summarises the language data collected in the watching scenarios.

Condition	Average score	Average previous knowledge	Knowledge gain
1 (English subs) - A	0.44	0.38	+ 0.06
2 (Italian subs) - B	0.57	0.23	+ 0.34
2 (Italian subs) - C	0.61	0.45	+ 0.16
3 (partial) - D	0.41	0.33	+ 0.08
3 (complete) - D	0.46		+ 0.13

Table 8
Watching students: average results for the language questions.

Compared to the subtitling students, the watching students showed a generally lower previous knowledge, and generally lower average scores. The value that really interests us, however, is knowledge gain. Video A, with English subtitles only, produced a knowledge gain of only 0.06, compared to an average knowledge gain of 0.27 by the subtitling students who worked on the same video, and a general average knowledge gain of 0.33 by the subtitling students at large. Video B, with Italian subtitles, produced a knowledge gain of 0.34, a value that is very close to those of the subtitling student who worked on the same video (0.36) as well as to the general average knowledge gain of the subtitling students at large (0.33). Interestingly, the watching students' average previous knowledge of this video is the lowest of the four. With Video C, also with Italian subtitles, the watching students fared poorly, with a knowledge gain of 0.16, compared to an average knowledge gain of 0.27 by the subtitling students who worked on the same video, and a general average knowledge gain of 0.33 by the subtitling students at large. Finally, Video D, in which the watching students benefited from both English and Italian subtitles, as well as of the advantage of knowing in advance which questions will be asked at the test –

i.e. which words to focus on while watching – showed a knowledge gain as low as 0.13. With the same video, however, the subtitling students did not fare much better, with an average knowledge gain of only 0.11.

Finally, these data show great variability depending on video, confirming that factors other than previous knowledge and type of subtitles have an impact on vocabulary acquisition.

3.5 Students' interest

The third section of the questionnaires aimed to establish the participants' interest in science in general and on the topic of the video in particular, before and after the experiment. The two groups declared similar levels of general interest in science, with an average of 2.44 for the watching group and 2.54 for the subtitling one (the difference between the two groups on this value is 0.10. Furthermore, both groups declared that the video had increased their interest in the specific topic, but the subtitling students reported a much greater value (average: 3.08 vs. 2.44, with a difference between the two groups of 0.64).

4. Conclusions

The current study took advantage of existing teaching modules with students specialising in foreign language learning and translation to collect data about the impact of subtitling (i.e. creating subtitles) on content acquisition, language acquisition, and student's love for science.

A group of students – here called 'subtitling students' – created English and Italian subtitles of a set of short videos in English about chemistry and physics. Subsequently, four of the videos accompanied by English and/or Italian subtitles were shown to a different group of students – here called 'watching students'. All the students were tested on the content and language in the videos. The subtitling students were tested about seven days after completion of the work, while the watching students were tested immediately after watching the video. For each item in the questionnaire, the participants were required to declare their prior knowledge by choosing from given alternatives. This helped researches to establish the extent to which results could be attributed to actual learning during the experiment, rather than to prior knowledge.

Results showed that both activities (watching subtitled video, and creating subtitles) helped content understanding and language memorization. This is in keeping with the existing literature on subtitled video and subtitling, reviewed in Section 1.

A comparison between the two types of activities was also attempted, in order to have a more concrete idea of the scale of the effect of the subtitling task. For content questions, the results of the watching group were much lower than those of the subtitling group, despite similar or slightly higher previous knowledge of the former. For language questions, the knowledge gain of the watching group was, on the whole, slightly lower or similar to those of the subtitling group. In the light of the facts that the students who watched subtitled video were tested immediately after watching the video, while the students who created subtitles were tested after a much longer period of time (about seven days after completion of the subtitling task), and that the watching students knew they would be tested on the contents and language of the videos, while the subtitling students were not aware of this, this comparison suggests that creating subtitles is probably a much

more powerful activity for language and content acquisition than watching subtitles. This does not come as a surprise, given the larger amount of time the subtitling students spent on the videos while working on the two subtitling tasks, and the attention that translating and subtitling requires from the subtitler (Williams and Thorne 2000, in Section 1).

Finally, both activities increased the student's interest in science, but the subtitling group's declared increase is greater than that of the watching group.

These findings suggest that creating subtitles would be a very useful activity in pedagogical scenarios focussing on the acquisition of specialised content and specialised language, such as CLIL or content-based instruction in a foreign language.

Despite the interesting results above, this study has several shortcomings and does not provide conclusive evidence of the superiority of subtitling over watching subtitles with reference to content and/or language acquisition. Further empirical research is needed. In particular, long-term results from both groups should be compared. It would also be interesting to assess the impact of factors distinguishing different videos – such as video length, speed of speech, and image congruity with spoken words – on the two types of activities. Finally, it would also be useful to test the subtitling pedagogical scenario adopted in this study with students majoring in science.

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Appendix

C60 and Nanotubes

Rispondi in italiano alle seguenti domande sui contenuti scientifici del video. Nella colonna Conoscenza pregressa, specifica se conoscevi la risposta alla domanda prima dello svolgimento del project work, scegliendo tra le seguenti alternative:
1. non sapevo nulla; ho imparato tramite il project work;
2. sapevo qualcosa sull'argomento ma questo specifico aspetto l'ho appreso nel project work;
3. conoscevo già questo aspetto della materia; il project work mi ha aiutato a rinfrescare la memoria;
4. conoscevo già questo aspetto della materia; avrei potuto rispondere a questa domanda anche prima del project work.

	CONOSC. PREGRESSA
1) Quali sono le 3 forme pure di carbonio note finora in natura?	
2) Qual'è la forma di una molecola di C60?	
3) Di quanti atomi si compone il C60?	
4) Come si può ottenere il C60?	
5) In una molecola di C60 gli atomi di carbonio si combinano formando 2 precise figure geometriche. Quali?	
6) Secondo quali figure geometriche raggrupperesti i singoli atomi di carbonio per ottenere un semplice foglio piatto di carbonio? E per formare una superficie cilindrica?	
7) Quanti tipi di nano tubi si possono creare piegando un foglio di grafite?	
8) Quanto e' grande il diametro di un nanotubo?	
9) Elenca almeno 3 caratteristiche dei nanotubi che ne rendono un materiale interessantissimo dal punto di vista delle sue possibili applicazioni.	

Nella tabella di seguito, fornisci una traduzione per i termini specificati, nel contesto del Video C60 and Nanotubes.
Per ogni coppia di termini, nella terza colonna, indica come hai risolto quel particolare termine nella traduzione dall'inglese all'italiano, scegliendo tra le seguenti opzioni:
1 = non lo avevo mai sentito e ho fatto ricerche per capirlo e per tradurlo;
2 = non lo avevo mai sentito e ho fatto ricerche per capirlo; una volta capito il significato, sapevo da solo come tradurlo;
3 = non lo avevo sentito ma dal contesto risultava chiaro; non ho fatto ricerche perché sapevo da solo come tradurlo;
4 = non lo avevo sentito ma dal contesto risultava chiaro; ho fatto ricerche per verificare la mia ipotesi traduttiva;

5 = li conoscevo bene sia in italiano che in inglese; non ho fatto ricerche.

ITALIANO	INGLESE	CONOSC. PREGRESSA
Esagono		
Pentagono		
Grafite		
Diametro		
Nanotubo a spirale		
	The caps of the nanotubes	
	Steel	
Conduttività elettrica		
	to fine-tune	
Nanotubo isolante		
Nanotubo semiconduttore		

RISPONDERE CON UN NUMERO DA 1 A 4:
1 = NULLA
2 = POCO
3 = ABBASTANZA
4 = MOLTO

Quanto ti appassionano in generale le materie tecnico-scientifiche?	
E' aumentato il tuo interesse sull'argomento trattato nel video dopo aver completato il lavoro di trascrizione e sottotitolaggio?	