Veiga-Diaz, M. T. (2023). Colour as a metacognition-enhancing strategy in scientific translators' education. *Current Trends in Translation Teaching and Learning E*,10, 77 – 108. https://doi.org/10.51287/cttl20234

COLOUR AS A METACOGNITION ENHANCING STRATEGY IN SCIENTIFIC TRANSLATORS' EDUCATION

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Abstract

Colour is one of the codes that has proved successful in helping students retrieve knowledge, become aware of their strengths and weaknesses and provide them with an opportunity to improve their knowledge, skills and confidence effectively. Using descriptive statistics and hypothesis testing, this paper presents a comparative analysis of the performance of an experimental group of students who received colour-coded feedback and a control group of students who received non-coded feedback. The analysis is aimed at determining the contribution of colour-coded feedback to successful error identification and correction and the development of metacognitive activity. The results of this study point to more successful error correction in self-revisions and improved performance in translation, revision and reflection tasks among the students who received colour-coded feedback. This project is suggestive of enhanced metacognition, particularly for the specificities of scientific and technical translation.
Keywords: colour coding, metacognitive bundling, constructive feedback, scientific translation, translator education

1. INTRODUCTION

Learning involves a change in knowledge, competence, attitude and behaviour and is affected by factors such as our prior knowledge or competence, our social and emotional experiences, and the way we organize knowledge. When knowledge is organized, we are better able to retrieve and apply it effectively and efficiently. On the contrary, when knowledge is connected randomly, i.e., when metacognitive bundling does not occur, we often fail to retrieve it or apply it properly, which will probably make us feel less confident (Ambrose et al., 2010; Angelone, 2015; Angelone & Shreve, 2011). As suggested by Echeverri (2015), goal-oriented reflective practice combined with constructive, targeted feedback helps translation students engage in various metacognitive processes aimed at improving their capability to monitor and evaluate their learning process, which will eventually lead them to better organize knowledge and improve the quality of their learning. In the field of translator competence acquisition, recent studies have pointed to the need to incorporate tasks that contribute to improving the metacognitive activity of students by enhancing self-awareness and self-efficacy (Araghian et al., 2018; Ayllón et al., 2019; Chen, 2019; Haro Soler, 2019; Konttinen, 2022). This is the case for self-revision and reporting, a learner-centred, process-oriented approach aimed at error detection and classification that can be used after an initial product-oriented assessment to dig deeper into the process and improve translation-related knowledge (Angelone, 2021, p. 156).

We agree with Washbourne (2015) that, in translation pedagogy, errors must be considered as learning aids to gain a deeper understanding of the translation process, rather than as something to be avoided. By reflecting on errors and classifying them, learners are allowed to abstract their guiding principles and find links between product and process. Yet, because the error categories available are not always suited to the learning goals and outcomes envisaged in specific modules, researchers are striving to find renewed and updated categories of errors that help students focus on translation both as a product and as a process, and recognise a broader number of error categories (Angelone, 2019, 2021). In the case of scientific translation, Brugué and Giró (2015) used quantitative and qualitative correction scales to assess the errors made by students, but the categories they used were not specifically related to scientific and technical translation. Similarly, Mellinger (2019) focused on problem recognition and solution evaluation in self-assessment reflection essays and found that students reported translation problems related to three categories, namely terminology, neologisms and phraseology, but were scarcely aware of the specialized translation process and hardly reflected on the tasks. He found that increasing task awareness contributed to improving metacognitive behaviour among specialized translation students but he acknowledged that further work was needed to develop metacognitive activities to target specific aspects of translation learning.

One way of enhancing students' awareness of errors and their relation to the translation process is reflective revision based on instructor feedback, which is, by nature, a metacognitive activity that requires a response from students (Echeverri, 2015, p. 315). In this sense, Moser (2020) suggests that colour coding or error indication can be an appropriate first step in reflective revision, particularly in dynamic processes, such as translating. In fact, in translation pedagogy, error indication has been often used as a first step in reflective revision, which is conceived as a two-way channel in which the teacher pre-checks the translations of students and marks problematic areas, but does not make suggestions as to how to amend the texts (Chodkiewicz, 2015, 2018; Pietrzak, 2019; Moser, 2020). In general, using feedback codes is helpful because they provide students with clues about error categories and a shared set of specific criteria for further tasks (Andújar Moreno & Cañada Pujols, 2021). Thus, feedback codes trigger metacognitive reflection and help students know better how they translate through retrospective reflection on their translation problems and strategies (Angelone, 2015, 2019). In particular, it has been demonstrated that students who reflect on their translations with highlighted or coded fragments are more likely to self-correct their translations, rethink what was problematic for them and consider the categories of problems (Shintani & Ellis, 2013, p. 288; Chodkiewicz, 2018; Pietrzak, 2019, p. 112). Yet, some students fail to take action based on error markings (Chodkiewicz, 2018), which can be indicative of poor metacognitive activity. Despite this limitation, reflective feedback allows teachers to analyze whether and how feedback is transferred to students' performance in the revised versions of their translations and in new translations (Washbourne, 2014, p. 13), which is essential to bring about change.

2. COLOUR AND METACOGNITIVE ACTIVITY

Colour is one of the codes that has proved successful in helping students retrieve knowledge about the task at hand. As claimed by Dzelzkaleja and Kapenieks (2016, p. 269), colour codes help students become aware of their strengths and weaknesses and provide them with an opportunity to improve their knowledge, skills and confidence in a way that is more effective. It has been demonstrated that the use of colours can increase the retention rate of graduate students (Olurinola & Tayo, 2015) and enhance memory performance by improving their level of attention (Dzulkifli & Mustafar, 2013; Sattarzadeh & Boroujeni, 2021). In addition, we must take into account that colour associations with emotions or concepts help students remember (Chang et al., 2018), provided that the code is congruent and consistent (Dzulkifli & Mustafar, 2013; Olurinola & Tayo, 2015).

In agreement with Murray (2014) and Moser (2020), using a colour code to mark students' translations can be a good practice to trigger metacognitive reflection about how they learn. Indeed, colour codes immediately direct students' attention towards specific issues, increase students' self-awareness of their learning (Hamid et al., 2018), provide an organizational schema for writing improvement (Storke, 2015) and enhance students' engagement (Moser, 2020). In line with our research, Moser (2020) combined colour coding with other types of written corrective feedback, among which self-correction and a personal written report, and found that combining several feedback methods fostered learner engagement. In her study, students found self-correction led them to deep learning because it required reflection on errors and potential solutions. In addition, students were able to connect the colour code with the second draft of the task. They felt that knowing which category of error they had made, they had the opportunity to do it better, think about why it was wrong and provide their corrections. Despite these benefits, sometimes self-correction is not so popular among students because it is time-consuming and involves a lot of effort on the learners' part (Moser, 2020, p. 60), particularly if no other hints are provided by the teacher. In translation pedagogy, Andújar Moreno & Cañada Pujols (2021) explored various corrective feedback methods and found that translation teachers who applied colour codes for marking translations used between two and five colours, one of which, usually green, was used to mark good solutions. The most common approach was using a kind of "traffic light", with green for good solutions, yellow for minor errors, and red for major errors. Yet, this approach neglects the effects of each colour on cognitive activity.

Not every colour has the same impact on learning, with some colours bringing about more intense neuronal activity in the brain than others. For example, among VIBGRYOR colours (Violet-Indigo-Blue-Green-Yellow-Orange-Red), blue causes the greatest brain activity, followed by red and green, whereas yellow, indigo and grey cause the lowest brain activity (Roy et al., 2021). Among these, red, blue and green are perceived more actively. Particularly, red stimuli have been shown to receive an attentional advantage, but some authors claim that they undermine intellectual performance and increase caution and avoidance (Elliot, 2015) because they are associated with negative affectivity (Gnambs, 2020). In contrast, blue shades increase mental alertness and performance on attention-based tasks (Elliot, 2015) because they encourage thinking and reflection (Sattarzadeh & Boroujeni, 2021).

In a recent preliminary perception study (Veiga-Díaz, 2023), we found, in agreement with Angelone (2015) and Mellinger (2019), that students often found it difficult to identify errors and determine which resources would be optimal in addressing them, which affected their self-efficacy. To help students improve their learning by enhancing metacognitive bundling, we implemented a pedagogical method based on constructive alignment, translation competence acquisition and process-oriented learning (Veiga-Díaz & García-González, 2016) that combined assisted translation revision with self-reporting. In assisted revision, we marked the initial translations of students with a colour code to help students become aware of their strengths, problems and errors, and categorize them. Increased awareness should contribute to improving students' confidence, as well as their ability to correct errors and improve the quality of further translations (Haro Soler, 2018). In self-reporting, students were asked to trace possible causes for their errors and find the correct problem-solving strategies for each category of error, thus engaging in metacognitive bundling (Angelone, 2015; Angelone & Shreve, 2011; Mellinger, 2019). The results of our preliminary perception study revealed that the assisted revision method helped students improve the correspondence between their self-efficacy beliefs and their actual performance, thus enhancing learning (Konttinen, 2022). As regards students' beliefs and attitudes, they strongly agreed that the feedback given by the instructor in the form of colour marking had helped them better identify the errors they made when translating and to improve their translation process, which they acknowledged had changed and become more reflective. These findings encouraged us to conduct a further study based on the same method to test to what extent the use of colour-coded marking helped students improve their translations by correcting more errors (improved knowledge retrieval) and enhancing metacognition by making fewer new errors (improved knowledge application). Below, we present the materials and methods, the results and the conclusions of our study.

3. MATERIALS AND METHODS

3.1 Research questions and hypotheses

The preliminary analysis of the results of the implementation of an assisted-revision method that combined colour marking of errors and self-reflection raised the question as to whether the use of colour coding contributed to learning, as perceived by students. The results pointed to a beneficial effect of the use of colour-coded feedback on metacognitive activity, insofar as students improved the identification of their translation problems and reduced the number of errors made both in self-corrections and in further translation tasks (Veiga-Díaz, 2023). Yet, our preliminary study did not compare the results of students who did not receive colour-coded feedback with the results of students who did. For this reason, we have broadened the scope of our preliminary study to analyse the indicators of the contribution of colour-coded feedback to successful error recognition and correction. The present research is based on the following research questions:

- Do students who receive colour-coded feedback perform better in translation, revision and reflection tasks?
- Do students who receive colour-coded feedback successfully correct more errors in the self-revised version of their translations?
- Do students who receive colour-coded feedback progress show a higher rate of error decrease from the beginning to the end of the semester?

Based on the literature review conducted and on the results of our preliminary perception study, we formulated the following hypotheses:

- By the end of the semester, the students who receive colour-coded feedback will perform better in translation, revision and reflection tasks than the students who receive non-coded feedback.
- Students who receive colour-coded feedback will successfully correct more errors in the self-revised versions of their translations.
- Students who receive colour-coded feedback will commit fewer errors in further translation tasks.

- The rate of error decrease from version 1 of Assignment 1 to version 1 of Assignment 3 will be higher for students who receive colour-coded feedback.
- Students who receive colour-coded feedback will introduce fewer new errors in the self-revised versions of their translations.

3.2 Participants and tasks

The study was conducted within the framework of a Scientific and Technical Translation module taught during the seventh semester of the four-year undergraduate program in Translation and Interpreting at the University of Vigo and designed according to the principles of constructive alignment, translation competence acquisition and process-oriented learning (Veiga-Díaz & García-González, 2016). Particularly, the module is aimed at helping students acquire competence in the specificities of scientific and technical translation and writing, namely increased levels of accuracy, advanced use of scientific and technical writing strategies and a high degree of intervention in the text (Byrne, 2010; Veiga-Díaz, 2020). The study covered three academic years, from 2019 to 2022, and all 76 students enrolled in the module throughout the three years took part in the research. The participants were divided into two groups: an experimental group composed of 53 students who received colour-coded feedback and a control group composed of 23 students who received non-coded feedback, consisting of underlining errors without further clues about the categories of the errors marked.

During the semester, students were asked to perform and deliver three translation assignments, labelled A1, A2 and A3, two of which were individual assignments (A1 and A3) and one of which was a collaborative assignment developed in small groups (A2). A1 and A2 comprised the following tasks: a prospective reflection on the source text and the potential translation problems/difficulties (context), an initial version of the translation (V1), a retrospective self-reflection report that included reflection on errors, error causes, changes made and resource use (reflection and resources), and a revised version of the translation (V2). In contrast, A3 consisted of performing and delivering a single translated version of a text, with no associated reflection tasks, because it was scheduled at the end of the semester when students usually have more academic pressure due to work overload. All students were given ten days to perform and deliver the initial version of the translation, and the instructor provided feedback for the translation in two weeks. Initial feedback consisted of a holistic assessment of the translation based on professional standards, which provided the students with an overall impression of the quality of their translation and of the amount of revision required to reach a professional standard (Akbari & Segers, 2017, p. 412). The instructor marked the errors in V1 and returned the translations to the students. In the control group, errors were underlined using only one colour for all the categories. In contrast, in the experimental group, translations were marked using a colour code to foster metacognitive activity. Colours were assigned to error categories based on the level of brain activity induced and the psychological associations involved. Thus, red was assigned to the most serious errors, whereas two shades of blue were assigned to scientific writing errors, which were the focus of the module and required increased mental alertness and reflection. For this research, scientific writing errors were defined as solutions that deviated from scientific writing goals, which included inaccurate terms or expressions, unclear words or sentences, unconcise expressions, unsmooth text segments or unfamiliar words or expressions (Alley, 2018). General translation errors, such as mechanics and grammar or calques were assigned to the colours with the least influence on brain activity, yellow and grey, respectively (Figure 1).

Figure 1. Colour code

Colour	*Meaning*	*Category*
magenta	Particularly good solution	Any category
grey	Calque	General translation /writing
red	Major error: contresens/omission/spelling	
yellow	Mechanics: grammar/syntax/punctuation	
olive green	Formatting	Format
petrol blue	Accuracy	Scientific language goals
cyan	Clarity/concision/fluidness/familiarity	

The individual feedback provided by the instructor was complemented by a classroom discussion session, during which all the students had the opportunity to ask questions about their markings. Based on this feedback, the students revised their products, prepared a final version of their translations and wrote a self-report that comprised a categorization of the errors marked by the teacher, a justification for every error, and their reflections on the processes followed to reach every solution and on how to apply their learning to further translations. All the tasks were assessed according to five performance levels, namely minimal (1), deficient (2), acceptable (3), strong (4) and standard (5), using the same rubric used in the preliminary perception study (Veiga-Díaz, 2023), which covered the following items:

- Initial version of the translation (V1).
- Prospective reflection on the source text problems and difficulties (Context).
- Retrospective reflection on errors (Reflection).
- Use of resources (Resources).
- Revised version of the translation (V2).

A comprehensive description of the characteristics of the assignments, the types of texts and the rubrics used for assessment is provided in Veiga-Díaz (2023).

3.3 Methods of analysis

The influence of colour-coded feedback on metacognitive activity and its role in error categorization and correction in the scientific and technical translation classroom was analysed based on two parameters: 1) the overall performance of students who received colour-coded feedback (experimental group - EG) and of students who received non-coded feedback (control group - CG) as evinced from the scores obtained throughout the year and 2) the evolution of the number of errors made by students. Both parameters were analysed using descriptive statistics and hypothesis testing. The following statistical measures were calculated: the means for the scores of the three tasks, the frequency of errors in each category and the rate of error decrease from A1V1 to A3V1 and from A1V2 to A2V2.

A Student's t-test for independent samples was used to determine whether the differences between the performance of the experimental group and the performance of the control group were statistically significant, i.e., to determine a probability that the results of the two types of feedback were significantly different. The following indicators of performance were analysed:

- Holistic scores for the tasks included in the assignments.
- The mean number of errors in A1V1 vs. the mean number of errors in A3V1.
- Mean number of errors in A1V2 vs. mean number of errors in A2V1
- Mean number and percentage of errors corrected in A1V2 and A2V2.
- The mean percentage of errors left unchanged in A1V2 and A2V2.
- Mean number of new errors introduced in A1V2 and A2V2.

The results of the quantitative and qualitative analysis of the three translation assignments are presented below.

4. RESULTS

4.1 Overall performance in translation, revision and reflection tasks

The overall performance of the participants was assessed based on the means for the scores obtained in all the translation and revision tasks completed during the semester (Table 1).

Table 1. Evolution of mean scores for translation and revision tasks

Assignment	Task	Mean score		Mean diff.	Student's
		EG	*CG*		

					t-test significance
A1	*V1*	2,11	2,09	0,02	0,945
	V2	3,39	2,59	0,80	0,003
A2	*V1*	2,27	2,22	0,05	0,854
	V2	3,63	3,04	0,58	0,122
A3	*V1*	3,20	1,78	1,41	<0,001
Rate of variation	*A1V1-A3V1*	52%	-15%	695%	
	A1V2-A2V2	7%	17%	-27%	

4.1.1 Translation and revision tasks

At the beginning of the semester, no significant differences were found between the scores of the initial translations (*V1*) for the experimental and the control group, which suggests a similar starting point for all the students, whose translations required major revision to reach the standard.

However, significant differences were found between the initial versions of the experimental and the control group by the end of the semester. Furthermore, the scores of the students who received colour-coded feedback increased steadily from A1V1 to A3V1 and reached an acceptable level, requiring only minor revision to reach the professional standard, whereas the mean scores for the initial versions of the group who received non-coded feedback hardly increased from A1V1 to A2V1, and even decreased for A3V1, still requiring substantial revision. This is indicative of a steady increase in metacognitive activity reflected in improved knowledge application for the group who received colour-

coded feedback that led to improved translation quality by the end of the semester, after two complete reflection cycles.
As per the revised versions of the translations, the Student's t-test revealed significant differences for A1V2 but not for A2V2, which corresponded to the collaborative assignment. The differences between groups reduced considerably in collaborative revision. Nevertheless, the group who received colour-coded feedback performed better than the group who received non-coded feedback.

4.1.2 Reflection tasks

As shown in Table 2, no significant differences were found between the mean scores for reflection tasks at the beginning of the semester (A1), with similar performances for both groups, yet with slightly higher scores for the control group in all the activities.

Table 2. Evolution of mean scores for reflection tasks

Assignment	Task	Mean score		Mean diff.	Student's T-test significance
		EG	*CG*		
A1	*Context*	2,23	2,50	- 0,27	0,256
	Reflection	2,32	2,55	- 0,22	0,444
	Resources	2,38	2,55	- 0,17	0,595
A2	*Context*	3,39	3,69	- 0,30	0,200
	Reflection	3,43	2,61	0,82	0,002
	Resources	3,71	3,09	0,63	0,010
Variation A1 - A2	*Context*	52%	48%	- 11%	
	Reflection	48%	2%	472%	
	Resources	56%	21%	471%	

In assignment 2, significant differences were found for self-reflection and use of resources, with the experimental group performing significantly better in retrospective reflection. Conversely, no significant differences were found for prospective reflection (contextualization and analysis), which improved at the same pace for both groups irrespective of the type of feedback. This finding suggests that the ability of students to analyse the source text and find the links between source text analysis and its contribution to anticipating problems and errors is not influenced by the type of feedback, which is in agreement with Mellinger (2019, p. 608). Conversely, the significant improvement observed for retrospective reflection among the students who received colour-coded feedback points to a relevant contribution of colour coding to the classification, justification and correction of the errors marked by the instructor, helping these students organize their knowledge better than the students who received non-coded feedback.

In brief, based on the results of the t-test for Equality of Means, at the beginning of the semester, the mean scores for all the items included in assignment 1 were statistically equal, which means that the starting point was similar for students in both groups. As the semester progressed, the students who received colour-coded feedback performed significantly better in individual translation and revision tasks, and also in all the retrospective revision tasks. These results suggest that improving retrospective reflection helps students improve the quality of their translations, which is indicative of improved knowledge application and increased metacognition. Below, we present the results for the evolution of the number of errors.

4.2 Analysis of the evolution of the number of translation errors

4.2.1. Evolution of the number of errors in initial versions (V1)

The evolution of the number of errors in the initial versions of the translations suggests a remarkable improvement in the performance of the experimental group (Table 3). Both groups improved their performance throughout the semester, but our results are indicative of a stronger increase in metacognitive activity and improved knowledge application in students who received colour-coded feedback. In fact, at the beginning of the semester, the students in the control group made significantly fewer errors than the students in the experimental group but, by the end of the semester, such differences dissolved, and the means for both groups became statistically equal, with 120% decrease in the mean difference between groups and a slightly lower number of errors per 100 words in the experimental group.

Table 3. Evolution of the number of errors per 100 words in V1

Task	EG	CG	Mean difference	Student's T-test sign.
A1V1	12,81	9,28	3,52	<0,001
A2V1	5,62	4,66	0,96	0,016
A3V1	4,21	4,90	-0,69	0,141
Variation A1 to A3	-67%	-47%	-120%	

Per categories, the evolution of errors related specifically to scientific writing goals shows a similar trend, with students in the experimental group making significantly more errors in A1 and gradually shortening the distance with the control group, with statistically equal performances for precision in A3 and a dramatic change in the other scientific writing goals, as shown in Table 4.

Table 4. Evolution of errors per 100 words in V1 for scientific writing categories

Assignment	Precision				Other scientific writing goals			
	EG	*CG*	*Mean diff.*	*T-test sign.*	*EG*	*CG*	*Mean diff.*	*test sign.*
A1V1	4,33	2,85	1,48	0,003	4,60	2,75	1,84	**<0,001**
A2V1	2,49	2,12	0,37	0,123	2,51	1,81	0,70	**<0,001**
A3V1	1,51	1,32	0,19	0,448	1,00	1,83	-0,83	**<0,001**
Variation A1 to A3	-65%	-54%	-87%		-78%	-33%	145%	

For the 'other scientific writing goals' category, the students who received colour-coded feedback progressed from showing a significantly poorer performance in A1 and A2 to a significantly better performance than the students who received non-coded feedback in A3. All the students improved their performance in new translations, but the use of a colour code did seem to bear an influence on the ability of students to apply scientific-writing-related knowledge to further translations, as suggested by the sharp decrease in the difference between the means for both groups from A1 to A3. In effect, the progression of the experimental group is remarkable and points to considerable improvement in their metacognitive activity. These results point to a stronger level of reflection in the classification of errors related to scientific writing goals different from precision, which were marked with cyan colour, comprising errors related to clarity, concision, fluidity and familiarity. In addition, our results seem to confirm that blue shades increase mental alertness and performance on attention-based tasks and encourage thinking and reflection, which is in agreement with Elliot (2015) and Sattarzadeh and Boroujeni (2021).

The evolution of errors related to general translation problems does not show the same steady downward trend observed for scientific translation problems. Interestingly, all the students made significantly fewer errors in A2 than in A1 and A3 for all the categories, except for format. This could be due to the collaborative nature of the assignment, which required stronger revision. Nevertheless, the number of errors in individual assignments decreased sharply for both groups and all the categories, with significant differences by the end of the semester only for the *calques* category, in which the group who received non-coded feedback performed significantly better with a dramatic 159% decrease in the number of calques.

Table 5. Evolution of the number of general errors per 100 words in V1

Assignment	Error category	EG	CG	Mean difference	Student's T-test sign.
A1V1	*Mechanics*	1,20	1,53	-0,33	0,219
	Calques	1,34	1,67	-0,34	0,200
	Major	0,72	0,25	0,47	0,087
	Format	0,69	0,22	0,47	0,004
A2V1	*Mechanics*	0,40	0,30	0,10	0,250
	Calques	0,07	0,20	-0,13	0,003
	Major	0,02	0,20	-0,18	<0,001
	Format	0,14	0,04	0,10	<0,001
A3V1	*Mechanics*	0,75	0,90	-0,15	0,459
	Calques	0,59	0,39	0,20	0,020
	Major	0,26	0,23	0,03	0,860
	Format	0,10	0,22	-0,12	0,051
Variation	*Mechanics*	-38%	- 41%	-54%	

from A1 to A3	*Calques*	-56%	- 77%	159%	
	Major	-64%	-8%	-94%	
	Format	-86%	0 %	-126%	

No significant differences were found for errors related to mechanics and grammar, which evolved at the same pace. This is in agreement with Angelone (2015, p. 117), who suggested that there is a "tendency for syntactic problems to be somehow more salient than problems at other textual levels, to the extent that there seems to be a natural inclination to successfully detect problems of this type regardless of process protocol type used".

Overall, the use of a colour code has helped students focus on the problems related directly to scientific translation, which is the main goal of the module. The students who received colour-coded feedback significantly reduced their scientific translation errors as compared to the students who received non-coded feedback, who focused mainly on general translation errors, with mean differences of up to 145%. Similarly, the colour code was particularly useful for identifying formatting errors. The students in the control group showed no individual evolution from A1 to A3 in this area, with the same number of errors related to format in both tasks. Our results confirm the results obtained in the preliminary perception study (Veiga-Díaz, 2023), which suggested that the colour code helped students reflect on the specificities of scientific translation, instead of searching for general translation or writing problems. Focusing on general issues suggests a poorer ability to apply new knowledge to new translations and, consequently, poorer metacognitive bundling in the field of scientific and technical translation.

4.2.2. Evolution of the number of errors in revised versions (V2)

The t-test for equality of means for the number of errors made by the students in the experimental and the control group in the final versions of their translations revealed significant differences for both A1V2 and A2V2 (Table 6), with significantly fewer errors in the experimental group.

Table 6. Evolution of the number of errors per 100 words in V2

Task	Experimental group	Control group	Mean difference	Student's T-test
A1V2	1,94	2,89	-0,95	0,025
A2V2	1,50	2,49	-0,99	0,022
Variation A1 to A2	-23%	-14%	4%	

The ability of students to correct errors improved in both groups but was significantly poorer for the group of students who received non-coded feedback. Specifically, the students who received colour-coded feedback committed fewer errors in V2 and showed a higher rate of decrease between A1 and A2, which is directly related to their ability to identify, classify and correct the errors committed in V1. This is in agreement with the findings of Haro Soler (2018), who claimed that becoming aware of strengths, problems and errors helps students improve their ability to correct errors and improve the quality of further translations.

4.3 Analysis of the evolution of the percentage of errors corrected

In line with the above findings, significant differences were found for the mean number and percentage of errors corrected in A1V2 and A1V2 by the experimental and the control group (Table 7).

Table 7. Evolution of percentage of errors corrected in V2

Assignment		Experimental group		Control group		Mean diff.	Student's T-test sign.
		No.	*%*	*No.*	*%*	*%*	
A1V2	*Total*	12,64	98,70	7,51	80,93	17,77	<0,001
	Right	11,45	89,38	6,37	68,24	21,14	<0,001
	Wrong	1,19	9,29	1,14	12,29	-3	0,081
A2V2	*Total*	5,06	90,04	4,20	90,13	-0,09	0,031
	Right	4,64	82,56	3,46	74,24	8,32	0,002
	Wrong	0,43	7,65	0,74	15,87	-8,22	0,016
Variation A1 to A2	*Total*	-9%		49%		-100%	
	Right	-8%		9%		-60%	
	Wrong	-18%		30%		174%	

The students who received colour-coded feedback corrected a significantly higher percentage of errors than the students with non-coded feedback, both in A1 and A2. The difference in the percentage of total errors corrected in A2V2 shortened considerably, but the changes made by the students with non-coded feedback were often wrong. To be more specific, the mean difference in the variation of unsuccessful corrections between A1 and A2 increased by 174% as a result of the increase in successful corrections made by the students who received colour-coded feedback and the increase in unsuccessful corrections made by the students who received non-coded feedback. Indeed, students in the control group corrected 90.13% of the errors marked by the teacher in A2V1, but only 74% of the corrections were successful. In contrast, the students in the experimental group corrected 90.04% of the errors, with 82.56% of successful changes. These results suggest that using colour to mark and categorize errors improves awareness of errors and helps students successfully correct them.

4.3.1. Evolution of the percentage of errors left unchanged in V2

The analysis of the equality of means for the percentage of errors left unchanged in A1V2 and A2V2 revealed significant differences only for A1. By the end of the semester, the students in the experimental group increased the percentage of errors left unchanged. Yet, the number of errors left unchanged by both groups was negligible (<0,40 errors per 100 words).

Table 8. Evolution of percentage of errors left unchanged in V2

Assignment	Errors left unchanged						
	EG		CG		Mean diff.		Student's t-test sign.
	No.	*%*	*No.*	*%*	*No.*	*%*	
A1V2	0,41	3,20	0,98	10,56	-0,57	7,36	<0,001
A2V2	0,36	6,41	0,39	8,37	-0,03	1,96	0,714
Variation A1 to A2	100%		-21%		-73%		

Based on these results, the use of colour-coded feedback does not have a significant influence on the number of errors left unchanged. Yet, we must not forget that the decrease in the number of errors left unchanged by the students in the control group could contribute to the increase in the number of unsuccessfully corrected errors.

4.3.2. Evolution of the number of new errors introduced in V2

As in the case of errors left unchanged in V2, the analysis of the means for the percentage of errors introduced in A1V2 and A2V2 revealed significant differences only for A1. By the end of the semester, both groups introduced a negligible number of errors in the final versions of translations.

Table 9. Evolution of percentage of new errors introduced in V2

Assignment	EG	CG	Mean difference	Student's t-test sign.
A1V2	0,34	0,79	-0,44	0,002
A2V2	0,27	0,12	0,06	0,291
Variation from A1 to A2	-21%	-85%	114%	

The control group showed a remarkable evolution in this indicator, which suggests that error marking helps students reduce the number of errors introduced in the revised versions of their translations irrespective of the feedback method used. Yet, the use of a colour code speeds up the process because it helps students find the links between their errors and their strategies faster, thus favouring metacognitive bundling.

5. FINAL REMARKS

The comparative analysis of the performance of the students who received colour-coded feedback and the students who received non-coded feedback confirmed the contribution of colour-coded feedback to successful error recognition and correction and allowed us to verify the hypotheses that, by the end of the semester, the students who received colour-coded feedback: 1) performed better in translation, revision and reflection tasks, 2) successfully corrected more errors in the self-revised versions of their translations, and 3) progressed faster, showing a higher rate of error decrease from the beginning to the end of the semester. In agreement with Angelone and Shreve (2011), students were more successful in avoiding errors when problem recognition was bundled with error categorization and solution proposal and evaluation. Likewise, students who received colour-coded feedback focused on specific scientific and technical translation errors, which were marked using blue shades to increase mental alertness and performance. In this sense, the colour code helped students discern which errors were related to general translation strategies and which errors were related to specific scientific and technical translation strategies.

In contrast, we could not confirm our hypotheses that the students who received colour-coded feedback introduced significantly fewer new errors in the self-revised versions of their translations or committed significantly fewer errors in further translation tasks, at least for all the categories. Yet, there was a clearer and faster change in metacognitive activity over the semester in the group of students who received colour-coded feedback, who improved their ability to organize, retrieve and apply theoretical knowledge about scientific and technical translation and their specificities, as opposed to general translation problems.

These results suggest that the use of a colour code in assisted retrospective reflection can help students improve their reflections on their translation process and the quality of their translations and can be used to help translation students engage in various metacognitive processes (Echeverri, 2015). In addition, the use of a colour code revealed usefulness in the prospective analysis and detection of translation problems, which is indicative of an improvement in knowledge application.

In agreement with Moser (2020, p. 99), students needed some time to adjust to self-correcting their errors because they were not acquainted with the method and needed support from the teacher but, contrary to her findings, this reflective feedback method was overly time-consuming not only for students but also for teachers because it involves analyzing two versions of the translation and a self-reflection report in search of process difficulties. This was particularly true for the students who did not receive colour-coded feedback because of the extra effort required to categorize the errors marked by the teacher.

In the future, the presented method should be tested for inter-rater reliability and its results should be compared with screen recordings to determine whether students' reflections on their process are correct. Finally, an analysis of the influence of group work should be performed to verify the advantages and shortcomings of students' collaboration for the development of metacognitive activity.

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