# Collaborative Construction of a Wiki to Promote Self-Learning of Discrete Mathematics: A University Experience

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**Abstract** Discrete Mathematics teaching-learning processes are an area where significant learning is most difficult, then the use of novel methodological strategies is necessary. This work relates the process of collaborative creation of a wiki for a specific topic of Discrete Mathematics, process developed by students and monitored by the teacher. The main purpose was to evaluate the use of wiki as an educational resource to promote learning and the development of generic competencies. Students were evaluated before and a survey was administered to collect their perception of it. The results show that the development of the wiki had positive results: increase in qualifications, development of teamwork competency and other generic competencies, it was also possible to modify the role of the teacher and the interactions between students. In addition, it is concluded that both the activity and the methodology used can be an input for processes to improve educational quality.

**Keywords**: Wiki, cooperative learning, discrete mathematics, university teaching, active methodologies



## 1 Introduction

The current trend in educational processes is the creation of shared work environments in which teachers and students work together, either in person or remotely, in knowledge building processes. This trend is leading to the cooperative learning model being enhanced by the integration of technological tools such as virtual educational platforms and web 2.0 tools, so that the student is placed at the center of the learning process, a process that is built in collaboration with their peers, teachers and the context around them [1].

Mathematical education, like education in other areas of knowledge, is characterized by an ongoing process of transformation, some of the aspects involved in this transformation are the incorporation of new teaching-learning strategies and the integration of Information and Communication Technologies (ICT). Integration that is based on the very nature of mathematical reasoning that is not linear that resembles a network structure. On the other hand, understanding mathematical objects is not only reflected in verbal language, but also requires multiple representations.

In x it is further noted that, thanks to the interactivity of these tools, the student assumes a more active role that results in greater motivation towards study and the achievement of significant learnings [2].

There are many experiences of integrating ICT into learning teaching processes, however, in the field of Discrete Mathematics the experiences revolve around the implementation of virtual teaching-learning spaces [3, 4].

In [5] a didactic strategy for teaching discrete mathematics is used, in particular Boolean algebra, using Derive for Windows 6.0 and Multisim through virtual learning environments in order to obtain better use. In [6] a mixed model is implemented that includes the use of active methodologies and virtual classroom in the development of the subject Discrete Structures, the perception of students about the new model versus the traditional class model is collected.

In [7-10], a wiki is used in other specialties such as language, biology, psychology and accounting sciences, as a support instrument and reflections on the implications of its use for the teaching-learning processes carried out.

In this context, it is decided to propose an educational intervention consisting of students, supported by the teacher, building a wiki that will serve as a resource to support the teaching and learning processes.

While Web 2.0 offers different resources to make the student an active agent in the learning process, in light of the experiences carried out in other fields of knowledge, it seems that the wiki responds to the current demand for skills development generic skills that go beyond the specific knowledge of a subject and are necessary for the comprehensive training of the student.

Then, the main objective of this work is to evaluate if the digital educational resource “wiki” favors the evolution of learning and the motivation of students in the subject “Discrete Mathematics”, in particular in the topic “Coding Theory”.

## 2 Theoretical Foundation

### 2.1 Virtual Environment for Teaching-Learning

“Computer application designed to facilitate pedagogical communication between participants in an educational process, whether it is completely remote, face-to-face, or of a mixed nature that combines both modalities in different proportions… it serves to distribute educational materials in digital format (texts, images, audio, games, etc.) and to access them, to conduct debates and online discussions on aspects of the subject's program, to integrate relevant content from the network or to enable the participation of experts or external professionals in discussions or talks" [11].

From the different definitions in the literature, it is concluded that a virtual teaching-learning environment is a set of synchronous and asynchronous interaction environments, where, based on a curriculum program, the teaching-learning process is carried out, through a learning management system.

### 2.2 Teaching Mathematics with Technology Support

The teaching of mathematics, in addition to the rejection of apprentices, faces new challenges and new problems that place it in a phase of imbalance generated by the phenomenon of teaching massification, the evolution of social relations between students and teachers and the mathematical culture necessary to function in today's society.

The need of a citizen today goes far beyond knowing how to "count", because the current social context requires him to reason in situations of risk and uncertainty, decipher and know how to critically analyze the avalanche of codified information he receives [12].

On the other hand, learning technologies are changing the way we teach in the field of higher education, particularly in the field of mathematics. Teachers have been forced to test new teaching strategies, take advantage of online support, multidisciplinary and collaborative learning, and the integration of both mathematical and teaching supporting software.

Regardless of the resources used, the objective is to develop training processes that generate significant learning, for this, they must be based on the individual and social construction of knowledge always taking into account a critical and constructive position of the applications and limitations that digital technologies and mathematical knowledge have to solve problems [6].

### 2.3 Wiki

The term WikiWiki is of Hawaiian origin and means: fast. It is commonly abbreviated as Wiki. A wiki is a website that can be edited by multiple users asynchronously and through a web browser. The first wiki system is created under the premise of ease of use, that is, anyone can contribute to the content without having knowledge of programming languages or content management tools [13]. Wikis are an appropriate and efficient tool for students to develop meaningful learning; because its construction involves factors such as motivation, feedback, collaborative and active learning. For its part, [14] emphasizes the fact that if learners are content creators then their motivation is increased.

In the educational field, the use of a Wiki makes it possible for both students and teachers to collectively gather content in order to develop glossaries, build repositories, create textbooks, etc., so that they share responsibility for the project in which they work. For [15], transferring this responsibility to students can instill in them a sense of responsibility and belonging.

## 3 Context

The research is carried out at the Professional School of Systems Engineering of the National University of San Agustin (Arequipa, Peru), in which Discrete Mathematics is one of the axes on which specialty subjects are supported. This discipline begins with Discrete Structures I which is a prerequisite for studying Discrete Structures II,

subjects that are located in the first and second academic semesters respectively. For [6], these subjects are considered as critical subjects, within the mathematical component of the curriculum, since the failure rate is high; consequently, they are a bottleneck for student advancement.

The topic covered on the Wiki is "Coding Theory" and corresponds to Discrete Structures II. The Coding Theory is the study of techniques that enable efficient and accurate transmission of information from a source to a destination.

The teaching-learning processes of this topic are a challenge for teachers and students, this is due to the use of abstract algebra concepts: number theory, groups, rings and fields for understanding cryptography and coding theory.

# 4 Methodology

In the methodological framework, a quasi-experimental design was used in which mixed methods were used as they allow to generate more information regarding the phenomenon under study. This approach was able to achieve a broader view of the variables and benefits of the wiki in the cooperative work done by students for learning the topic "Theory of Coding".

In the qualitative phase, a non-participating observation sheet was used to assess the interaction between students and with the Moodle wiki tool; four categories were considered: the interaction of students with the wiki, the development of cooperative work, familiarity with the topic developed on the wiki and availability of resources.

In the qualitative phase, to study the evolution of academic results, a pretest and post-test on "Theory of Coding" was used, the results obtained were applied to the t-Student test. To collect student perception, a survey was conducted, implemented on the Moodle platform.

The population consisted of 40 students enrolled in group A of the subject "Discrete Structures II" of the Professional School of Systems Engineering of the National University of San Agustin in the academic semester 2019-II. Of these students towards the end of semester four left the course so the experience was carried out with 36 students.

## 4.1 Description of the Experience

### Roles of teacher and students

The experience described is developed under the mixed modality (b-learning), in which the virtual classroom is used as a support system for face-to-face attendance, so the teacher had to fulfill the functions: technical, academic, organizational and guiding contemplated in [16]. In addition, the teacher performs a monitoring function, so that he intervenes if the information is not correct, complete or doubts remain.

For their part, the students had an active participation in which they showed responsibility for achieve the goals, interacted with the contents and applied work techniques in groups.

**Performed activities**

Before starting the construction of the wiki, a master class was given on the subject under study and a pretest was carried out to evaluate the learning.

The first activity in the construction of the wiki was to ensure that there were equal opportunities to contribute to the wiki, for this purpose the basic instructions on its operation were given in a face-to-face session and subsequently published in the virtual classroom. In the same session, the subtopics were identified and distributed to the student teams.

To give feedback to students' contributions and ensure the quality of the wiki content, a draft of the contents was worked on a shared folder on Google-Drive.

For a support system to the construction of the wiki, a specific forum was opened in the virtual classroom.

Rubrics were used to evaluate both the cooperative work carried out by each of the teams and the wiki as a product of the cooperative activity.

The last action was to design a post-test to evaluate the learning again and be able to assess the wiki's influence on them.

**Activity design**

It was determined that the wiki construction activity would last three weeks, for this the scope of each of the subtopics was taken into account and that the wiki was the final activity planned in the subject.

Since a wiki is worked collaboratively, the key elements for developing a true cooperative learning enunciated by Johnson and Johnson [17] were taken into account: positive interdependence, individual and group responsibility, stimulating interaction, personal and group attitudes and skills, and group evaluation.

For the design of the activity, the proposed steps for the design of cooperative activities were adapted and implemented, steps that are formalized in [18].

For the formation of the groups and for the management of cooperative work, the characteristics worked in [19, 20]. Thus, the groups were made up of 6 students and three main roles were defined: academic manager, creativity manager and writing manager.

To follow up on the Wiki construction activity, students were asked to work on a draft of the contents in a shared folder on Google-Drive that would be accessed by the team members and the teacher; n this way, individual contributions could be identified and feedback on progress and proposals could be given. Likewise, they were told that they had to write a set of commitments (as objectives and tasks) that they would have to fulfill individually and as a team, this document would also be placed in this shared folder.

To assess the wiki, a rubric was developed in which three dimensions were scored: a) content organization, b) information quality and diversity of formats and c) evidence of information analysis (comparison, contrast, examples and/or conclusions). This rubric was published in the virtual classroom

# 5 Results and Discussion

## 5.1 Qualitative phase

The observation sheet recorded the situations that were observed during the development of the wiki and that were relevant to assess their influence on students' learning outcomes. Table 1 summarizes the findings of the qualitative phase.

**Table 1.** Situations observed in the qualitative phase.

| Category | Situations observed |
|---|---|
| Student interaction with the wiki | At the beginning of the activity the participation of the students was not very fluid; however, towards the second week of work, student participation increased notably. The forum activity created for this purpose encouraged participation and cleared doubts. |
| Development of cooperative work | The teams worked appropriately according to the principles of cooperative learning, were active, role performance led to positive interdependence and the stated commitments were fulfilled. Students gradually demonstrated confidence in the partner's work and skills to work cooperatively. |
| Familiarity with the topic developed in the wiki | Students took responsibility for the fact that they had to contribute creatively to the construction of the wiki, in that way they sought multichannel information that led them to a better appropriation of the contents worked. |
| Resources | One of the limitations was the time, because of the three weeks proposed, in practice they only worked hard in two. Other problems the space limitations and availability of computer equipment and internet service that the students had, which made it difficult for them to coordinate and perform the tasks that had been assigned. |

These results lead to affirm that the construction of a wiki allows to present content and learning support materials in different ways. At this point it coincides with [21] who also concludes that sharing, commenting and discussing them enables learning in any area of knowledge.

## 5.2 Quantitative phase

This phase includes the two moments of learning evaluation through written tests: pre-test and post-test on the topic " Coding Theory". Table 2 shows the descriptive statistics of the scores obtained in both tests and the t-test results for means of paired samples. The test was performed with the Excel data analysis-t-test for means of two paired samples.

**Table 2.** T-test for means of two paired samples

| | *Pre-test* | *Post-test* |
|---|---|---|
| Mean | 12.94 | 14.63 |
| Variance | 3.17 | 3.71 |
| Observations | 36 | 36 |
| Pearson's correlation coefficient | 0.76 | |
| Hypothetical difference of means | 0 | |
| Degrees of freedom | 35 | |
| Statistical t | -7.66 | |
| P(T<=t) one tail | < 0.001 | |
| Critical value of t (one tail) | 1.69 | |
| P(T<=t) two tails | < 0.001 | |
| Critical value of t (two tails) | 2.03 | |

Observing Table 2, it can be seen that there was an improvement in learning outcomes, the average in post-test increased by 1.68 points in relation to the pre-test average. To verify that this difference in the averages was not due to situations unrelated to the phenomenon under study, it was considered that the ratings came from the same study subjects at two different times, so the Student's t-test was applied for means of two paired samples. With a 95% confidence level, the following hypotheses were raised:

*$H_0$: There is no significant difference between the averages of the grades obtained in the pretest and the posttest*

*$H_1$: There is a significant difference between the averages of the grades obtained in the pretest and the post-test*

When analyzing the information in Table 2, it is found that the p-value for two tails is much less than 0.025, therefore the null hypothesis is rejected, this is confirmed by noting that the obtained t-value is in the reject zone marked by the critical value of t.

To gather student perception, a survey was carried out, implemented on the Moodle platform, which included 14 questions: an open question and the others of Likert scale.

The open question was **"What suggestions would you make to improve the activity?"** Some of the responses collected are listed below.

- *More freedom could be given in terms of content.*
- *Greater collaboration from my colleagues.*
- *I didn't like the wiki, it was very complicated to use, I don't think it's a very developed technology, one has many things to improve.*
- *Get to know the team members a little more.*
- *It would be interesting if each team can choose the editing format that best dominates, it is true that uniformity maintains order and this, but taking this suggestion into account could further exploit the creative potential of the students.*
- *It's very good.*

- *That there was a greater diversity of topics and that we could choose.*

To collect students' assessment in relation to the construction of the wiki, a Likert scale with scores 1 to 5 was used, from the "Totally disagree" option to "Totally Agree", being "Neither disagree nor agree" the middle position.

The coding of the answers was: 1: Totally disagree, 2: Disagree, 3: Neither disagree nor agree, 4: Agree and 5: Totally agree.

Table 3 shows the averages of the ratings expressed by students.

**Table 3.** Averages of activity valuations

| | Question | Means |
|---|---|---|
| 1 | It facilitated my learning about the subject | 3.82 |
| 2 | It helped me develop other skills: writing, spelling, etc. | 3.97 |
| 3 | Provided positive motivation for learning | 3.67 |
| 4 | It motivated the search for information. | 4.15 |
| 5 | Made learning the topic interesting. | 3.91 |
| 6 | The development of the activity was complicated for me. | 2.91 |
| 7 | I have actively participated in the activity. | 4.36 |
| 8 | It would have been convenient to spend more time developing the activity. | 3.61 |
| 9 | I had a clear idea of what I wanted to achieve as the final product of the activity. | 3.7 |
| 10 | Enhanced my commitment to studying and my sense of creative achievement | 3.88 |
| 11 | I would have preferred to create a website. | 3.64 |
| 12 | It would be preferable to work the WIKI on a topic explained more widely in class. | 3.82 |
| 13 | The scores obtained in the activity have seemed fair to me. | 3.36 |

As seen in Table 3, with the exception of question 6, satisfactory mean scores close to 4 points were obtained, so it can be inferred that students perceive the construction of the wiki as a productive activity that had an impact on their learning. It is important to note that in none of these cases does the level of indifference be reached.

## 6 Conclusions

The proposed objective has been achieved as there has been an increase in motivation towards learning discrete mathematics (in particular the topic "Theory of Coding") subject. There has also been an increase in academic results; therefore, the use of the wiki as a resource to support the teaching-learning of this subject has been beneficial.

The proper integration of digital technologies into teaching and learning processes can positively promote the appropriation of mathematical knowledge; to do this it is

necessary to use methodological strategies focused on the student and the interactions that they establish in their formative process.

Cooperative work supported in ICT makes individual and team contribution possible without the need to physically come together to carry out the task, each participant can contribute their own from wherever they are, can also propose modifications, so that the final version of the task is a consensual version by all the members of the team.

The wiki turns out to be an efficient resource for teaching and learning processes, because presenting the contents in various ways creates an important attraction towards learning.

In addition, the cooperative nature of its elaboration contributes to the development of generic competencies such as teamwork, leadership and communication. It also helps to develop information search skills and encourages the exchange of information and knowledge between students and with the teacher.

Particularly in the field of mathematics, students often believe that listening to the teacher's explanations is enough to understand what is being done, however, at the time of evaluation they realize that they had not internalized the concepts. On the other hand, with the elaboration of a wiki, a continuous process of content review is facilitated, content that can be presented in different formats (text, graphic, video, audio, etc.) facilitating its understanding.

The construction of the wiki also helps to bridge knowledge gaps and teacher's work, because in the construction process, it is possible to assess whether it is necessary to delve into a topic.

Finally, it is concluded that both the activity and the methodology used can be an input for processes to improve educational quality.

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