Virtual Reality, a Method to Achieve Social Acceptance of the Communities Close to Mining Projects: A Scoping Review

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***Abstract*—Background: Virtual reality (VR) technology is an effective, interactive and immersive type of communication since it produces greater interest and attention in the user, thereby allowing greater understanding and comprehension than with more traditional methods. On the other hand, not much information is known about the application of this novel technology in the context of social acceptance as far as the mining sector is concerned; our approach and methodology were based on scoping review (Prisma-SrC, Daudt et al., Arksey, and O'Malley). The research terms were also planned before, with the aim of carrying out three posterior screening levels, among which was the use of EndNote 20 and the PICO framework. Exhaustive research was carried out in nine databases. We obtained n=2 research articles of n=923 initially found, all of which went through three levels of filtering. The chosen articles were evaluated according to Hawker et al. 's methodological rigor, to be included in the review. This scoping review could be the starting point for a series of further investigations that would fill the gap in the literature on this topic, emphasizing experimental articles to confirm the impact of virtual reality technologies on the communities within the sphere of influence of a mining project.**

Keywords—Mining projects; social acceptance; virtual reality; interaction; mining communities

I. Introduction

Nowadays, virtual reality (VR) is present in a wide range of research fields, such as medicine, aviation, military activities and space engineering, architecture, entertainment, leisure, and mining, etc. [1-3]. According to a study of twenty years of research on virtual reality, its basic characteristics have evolved considerably, improving the interactivity produced between the user and the system human-computer interaction (HCI), in addition to perfecting the feeling of immersion that the user perceives while in the virtual world [4, 5]. Furthermore, virtual reality can be performed with exceptionally high quality, reproducing images and changing data three-dimensionally [6] providing a highly realistic simulation of the real world [7] and its continued development would facilitate the possibility of applying powerful new tools to influence the user's perceptual psychology [5].

On the other hand, social acceptance is related to the degree of tolerance that a community surrounding a mining project has for said project and whether or not the mining company can carry out its operations. This is considered very important since, without prior acceptance, the Social License to Operate (SLO) [8] would not be issued and, therefore, it would not start operations [9], generating economic losses to the company and the loss of benefits delivered to communities by mining companies [10] (mining taxes and royalties, direct and indirect employment).

Currently, energy and mining companies tend to justify their projects to the surrounding communities through the use of traditional methods and tools [11] which are usually represented by 2D images, plans and static drawings [6]. However, this does not guarantee either effective or convincing transmission of information with the community, which could create tension and conflicts due to misunderstandings among the stakeholders [10, 12]. A digital visualization of a landscape could stimulate public participation and allow for broader input regarding questions related with industrial projects [7].

The objective of this scoping review was to carry out an exhaustive investigation with the aim of determining the opportunities that the application of virtual technology could provide in support of mining projects and, based on the eventual findings, to identify gaps in the literature to help the planning and implementation of future research [13, 14].

A. Virtual Reality (VR)

This is defined as the hardware-software binomial, which works in the interaction with the user through effective synchronous communication [7], and it has the capacity for isolation from real life and immersion in a virtual life [15,16]. Virtual reality could also solve even more complex problems [15].

Immersive Virtual Reality (IVR) is defined directly with the concept of emphasizing the act of being present in the virtual environment, where the quality of immersion is directly proportional to the effectiveness of the experience [16], which may raise public awareness more effectively and result in a higher rate of acceptance of diverse projects [7]. In more simple terms, in order to obtain optimum results, you must work under the Triangle matrix of Virtual Reality (Interaction-Imagination-Immersion) [2, 3].

II. MATERIALS AND METHODS

For the purposes of this study, a PRISMA extension methodology for scoping reviews was employed (PRISMA-SrC) [13], as well as the methodology of Arksey and O'Malley [17] and Daudt et al. [18]. Furthermore, to provide added value to the scoping review, step six by Arksey y O'Malley [17] who considered the exercise of additional inquiry was carried out (Daudt et al. [18] y Levac et al. [19] discuss and consider it mandatory). As argued by Daudt et al. [18], too many people in a research group involves a risk that there will be several diverse interpretations during a scoping review; so it was decided to carry out this article with only four participating researchers.

A. *Search Plan*

First of all, before search criteria were developed, for which a variety of compiled tasks were carried out in August 2021 from nine distinct online databases: Scopus, Web of Science, IEEE, EBSCOhost and ScienceDirect ACM Digital Library, ERIC, SciELO, Google Scholar. The researcher (KV) supervised the means of obtaining data, as well as the use of Boolean operators and thesauri. The following link shows Table I detailing the databases and their search criteria.

TABLE I. SEARCH CRITERIA ACCORDING TO DATABASE USED

Electronic Databases	**Search Strategy**
IEEE	(("All Metadata":interact* OR "All Metadata":acceptance) AND ("All Metadata":publics OR "All Metadata":public OR "All Metadata":communit*) AND ("All Metadata":project* OR "All Metadata":compan* OR "All Metadata":mining) AND ("Document Title":"virtual reality" OR "Document Title":VR))
ScienceDirect	Title, abstract, keywords: (interact OR acceptance) AND (public OR publics OR community) AND (project OR company OR mining) Title: ("virtual reality" OR VR)
Scopus/Web of Science	Title, abstract, keywords: (interact* OR acceptance) AND (public OR publics OR communit*) AND (project* OR compan* OR mining) Title: ("virtual reality" OR VR)
EBSCOhost	Title, abstract, keywords: (interact* OR acceptance) AND (public OR publics OR communit*) AND (project* OR compan* OR mining) NOT (patient* AND rehabilitation) Title: ("virtual reality" OR VR)
ACM Digital Library	[[All: interact*] OR [All: acceptance]] AND [[All: public] OR [All: publics] OR [All: communit*]] AND [[All: project*] OR [All: compan*] OR [All: mining]] AND [[Publication Title: "virtual reality"] OR [Publication Title: vr]]
ERIC	(interact* OR acceptance) AND (public OR publics OR communit*) AND (project* OR compan* OR mining) Title: ("virtual reality" OR VR)
SciELO	((interact* OR acceptance) AND (public OR publics OR communit*) AND (project* OR compan* OR mining)) AND (title: (("virtual reality" OR VR))))
Google Scholar	CON TODAS LAS PALABRAS (interact acceptance public community project company mining) CON LA FRASE EXACTA (intitle:virtual intitle:reality)

The search criteria were limited to journals, conference papers, and reviews, with only publications in English from 2010 to 2021 taken into account. Subsequently, the search results were imported into EndNote 20 software, which is a reference manager that allowed us to proceed with the second filter. Later, the screening process was performed, and was based on the PICO framework (Population-Intervention or Exposure-Comparison-Results) [14].

B. *Screening Criteria*

The second review was carried out by two researchers (AA & JR), who used EndNote 20 to delete the duplicated articles. Additionally, the researchers identified, verified, and removed irrelevant articles manually. The third filter was performed under the PICO framework [14], with the aim of finding articles related to this research project. Each aspect of the eligibility criteria is detailed in Table II. Screening was carried out by performing manual searches in which all researchers participated (AA, KV, MB, PL, JR).

TABLE II. TYPE OF SCREENING USED FOR SELECTION OF STUDIES

Electronic Databases	**Search Strategy**
Population Communities in general.	Homogeneous communities, Clients, Patients
Intervention or Exposure Virtual Reality Technology (VR), Immersive Virtual Reality Technology (IVR), Cinematographic Virtual Reality Technology (CVR)	Non-Immersive Reality Technology (NIVR), Augmented Reality (AR) Technology, Smartphone Applications, 2D simulation technology.
Comparison Pre-test, Post-test.	If it lacks any evidence mentioned in the Inclusion Criterion, then it is discarded.
Results If it lacks any evidence mentioned in the Inclusion Criterion, then it is discarded.	If the approach is not related to Social Acceptance, then the article is discarded.

C. *Methodological Rigor*

The evaluation proposed by Hawker et al. helps to enhance the quality of this article in order for it to be useful and subsequently disseminated for future research [18]. The research articles that passed the three levels of filtering were evaluated according to the methodology of Hawker et al. [20] by two reviewers (AA, JR), according to the following evaluation criteria: "Good", "Fair", "Poor", and "Very Poor". This design framework allows us to evaluate a wide range of research methods. For this reason, we considered the parameters of Appendix D regarding to the methodological rigor analysis [20].

III. RESULTS

Table III, which contains the results of the evaluation of methodological rigor [20], resulting in the approval of the quality of both articles for the development of this scoping review.

TABLE III. RESULTS OF EVALUATION OF METHODOLOGICAL RIGOR APPLIED IN THE SELECTED STUDIES

Methodological Rigor Analysis	**Worth a thousand words: Presenting wind turbines in virtual reality reveals new opportunities for social acceptance and visualization research**	**The 3D Immersive Virtual Reality Technology Use for Spatial Planning and Public Acceptance**
1. Abstract and title: Did they provide a clear description of the study?	Good	Good
2. Introduction and aims: Was there a good background and clear statement of the aims of the research?	Good	Good
3. Method and data: Is the method appropriate and clearly explained?	Good	Good
4. Sampling: Was the sampling strategy appropriate to address the aims?	Good	Good
5. Data analysis: Was the description of the data analysis sufficiently rigorous?	Good	Good
6. Ethics and bias: Have ethical issues been addressed, and what has necessary ethical approval gained? Has the relationship between researchers and participant been adequately considered?	Good	Good
7. Results: Is there a clear statement of the findings?	Good	Good
8. Transferability or generalizability: Are the findings of this study transferable (generalizable) to a wider population?	Good	Good
9. Implications and usefulness: How important are these findings to policy and practice?	Good	Good
General Perception	Good	Good

Using the search criteria, n=923 articles were found, possibly related to the aim of the present research. Then, the information was screened until n=2 articles, according to their methodological rigor evaluation, as shown in Fig. 1.

A. Research Summary

An article selected and included in the present investigation emphasized its experimental objective by demonstrating that the use of technologies such as Immersive Virtual Reality (IVR) can be of great benefit to companies, mainly to provide a competitive advantage in the market [21]. The study was based on the range and variety of problems that wind energy projects go through before and during the construction process and it was demonstrated that the methods used to establish communication with the public are usually ineffective. Two tests were carried out before and one after the experimentation with 70 participants, where 50% were from the male population and the remainder from the female population. Additionally, the article highlights that 21.4% of the participants were over 28 years of age. The research findings showed an 8.6% increase in the post-test concerning the change in the participants' attitudes towards the proposed technology's general acceptance. Likewise, 40% of participants changed their perception in the pre-test, since the post-test results showed that 62.8% considered the project harmful to animals and the environment. On the other hand, 97.1% of the participants affirmed that immersive virtual reality technology was essential to change their attitude about energy projects, helping to better understand what they wanted to teach. On the other hand, only 38.6% of the participants considered 2D technology significant. The results found in this research show that the existing gap in communication between companies and people is reduced when implementing 3D IVR. It was also revealed that the use of this technology should play a more significant role in companies since it can unify the level of understanding between participants who are experts in a subject and those with less experience [21].

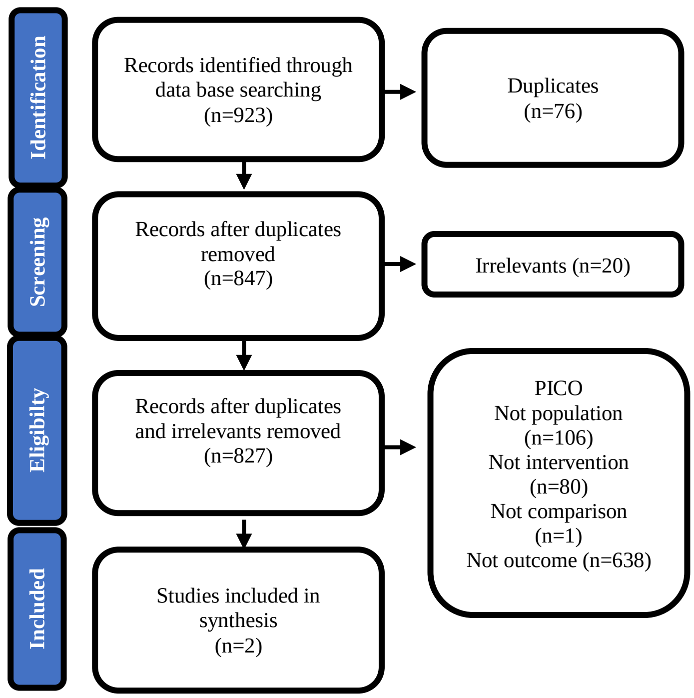

Fig. 1. Filter Stages and Selection of Studies.

Another article developed in the United States [11], investigates how the interaction, between the study population and the wind turbine represented by cinematographic virtual reality (CVR), influences the expectations and perceptions of wind energy projects. Specifically, it studies the relationship between personal appreciation of energy projects and changes in opinions after interacting with CVR. The population was recruited for the student-based experiment, all of whom were eligible to participate in the project, and the study group only knew about the subject from the mentions made by the recruiter, so it was considered a “naive population for the purposes of the study” (For this reason the authors include this article as part of the final filter of the quality review). A total of 101 students (47 women and 54 men) carried out an entrance survey to determine the population’s knowledge of before energy technologies. The questions are divided into seven categories: support and opposition, personal feeling, overall impact, impact on wind farms, attitude, knowledge, and visual and acoustic questions. 74% of the participants had never seen a wind turbine before, 54% had already experimented with virtual reality at some point in their lives, and 30% of the participants felt they knew enough about wind energy before experimentation. Afterwards, the participants underwent a test phase where they spent two minutes immersed in a virtual reality video to acclimatize and prepare the population. Participants who had never seen a wind turbine, and who did not know about it, were the ones who presented the most significant changes in their attitudes and opinions after the experiment. The experience turned out to have a high level of immersion and ecological validity, reducing erroneous beliefs about the different impacts of wind turbines- It can be assumed, therefore, that virtual reality can be profitably used to communicate more clearly the development of wind projects to the public in general, especially if the population's has poor knowledge of the subject. It goes on to propose that developers and politicians take such technological advances into account these since these are new tools which enable more effective interaction(s) with the population. A higher quality of image and audio in the presentation of a proposed project through virtual reality will help the public become more aware of and better understand the real impacts of the project and therefore will have greater influence in its acceptance [11].

You can see Table IV specifying the main characteristics of both articles.

TABLE IV. OUTSTANDING CHARACTERISTICS OF SELECTED STUDIES

Article	**Worth a thousand words. Presenting wind turbines in virtual reality reveals new opportunities for social acceptance and visualization research**	**The 3D Immersive Virtual Reality Technology Use for Spatial Planning and Public Acceptance**
Research Aim/ Objective	Examine how a multimodal and cinematographic virtual reality (CVR) experience with a wind turbine affects the expectations and perceptions of wind power projects. Specifically, we investigated the relationship between personal opinions about (renewable and non-renewable) energy sources, and variations in perceived impacts.	The objective is to evaluate the use of 3D virtual reality to support innovative SMEs in addressing issues related to spatial planning and corresponding public acceptance.
Outcomes	Students completed the experiment and approximately half (54%) had previously experienced virtual reality. Three quarters of the participants (74%) had never seen a wind turbine up close. About a third of all participants (30%) felt they were well informed about wind energy prior to the study. The CVR experience provided a high level of immersion and ecological validity. The CVR experience corrected previous erroneous beliefs regarding the expected visual and acoustic impacts of wind turbines.	There was a significant change in the perception of the participants before and after the session. For example, there was an increase of approximately 8.6% of the participants who positively changed their perception about the appearance of wind turbines. It also increased by almost 40% of participants who considered wind turbines as "bird friendly". The preference of people in 97.1% with respect to immersive virtual reality was also observed, tripling the result obtained in 2D technology.
Conclusions	In many cases, participants who had not seen a wind turbine before or who had felt less informed had greater changes in attitudes and opinions after the CVR experience. The participants felt immersed in the scene. Most of the participants considered that the wind turbine had a neutral or positive impact on the scene, although we cannot reject the null hypothesis that men and women reported feeling equally knowledgeable about wind energy. After the CVR experience, visual concerns about offshore wind farms having negative impacts on the landscape decreased. Taken together, these results suggest that CVR can be leveraged to more clearly communicate wind project development plans to the general public, especially when prior audience knowledge and experience with wind turbines is limited. We recommend that developers and managers, as well as politicians consider the proposed multimodal virtual experiences with wind turbines as a new tool to interact with the public. Accurately representing the visual and auditory characteristics of a proposed project through immersive visual and auditory simulations can help the public understand what to expect regarding project impacts, potentially allowing communities and developers to interact with one another more significantly.	The gap produced between companies and the public can be drastically reduced due to the implementation of 3D IVR As an SMEs. McCamley's management first reported a positive impact on the implementation of innovative 3D IVR within both its internal and external decision-making process. Internally, the company enriched its knowledge of the importance of technology in supporting engineering and management decisions, promotional events, and discussions with investors. In addition, dynamic simulation in the 3D IVR environment provides the public and the authority with a better understanding of the product. This allowed public support for one of the key product features; that of it being bird friendly. The commercial importance of the brand and color becomes a clear management decision because it can broaden public acceptance in terms of turbine appearance and shorten the payback

Article	**Worth a thousand words. Presenting wind turbines in virtual reality reveals new opportunities for social acceptance and visualization research**	**The 3D Immersive Virtual Reality Technology Use for Spatial Planning and Public Acceptance**
		period for investors. The company endorses the value of technology by integrating immersive 3D virtual reality into diverse management processes.
Methods and Methodology	The entry survey asked participants a series of questions about their opinions on different energy technologies in general and wind energy in greater detail. These questions were divided into seven categories: support and opposition, personal feeling, general impact, wind farm impact, attitude, knowledge, and visual and acoustic questions. During the testing phase, participants spent two minutes in a virtual museum in order to (a) acclimatize them to virtual reality, and (b) prepare them to put themselves in their place. A group asked about the visual and acoustic elements of the scene, including the volume and how well the wind turbine fit into the scene. Another group evaluated participants' previous experience with virtual reality and self-reported level of immersion in the scene using selected elements from Witmer and Singer.	A prior survey was conducted to measure the perception of 70 participants on wind energy projects. 10 sessions were held, and each session involved the participation of 5 to 9 people. After that the participants experienced 3D IVR, once the participants finished the experience, they carried out subsequent questionnaires to determine their changing perceptions.
Study Population	Participants were recruited between November 2018 and May 2019 and were compensated ($ 10 or course credit) upon completing the experiment. Participants were naive of the purpose of the study, although recruitment materials did mention wind energy. A total of 101 (47F, 54M; Age 19.5 years, SD Age 1.44 years) students completed the experiment and approximately half (54%) had previous experience of virtual reality. All students were eligible to participate in the study.	70 participants, of whom 50% were men, and 50% women. 21.4% were over 28 years old, 64.3% were participants with a history.

B. Stakeholder Views

According to a professional in mining operations, virtual reality would be an improved alternative when dealing with affected communities. This technology can surpass conventional methods in supporting mining projects within the surrounding areas and communities. Consideration should also be given to providing information and training through the application of virtual reality technology since it allows real time simulations similar to real experience, reducing risks, negative impacts and operating costs. He also commented that human-computer interaction (HCI) offers adequate retention, similar to mining training. A second professional (GP) said that this technology is used in shovels and mining trucks, claiming that it was a success. He argues that everyone in large mining projects invests in technology and virtual reality. He proposed to perform visual modeling of wind direction so that members of the surrounding communities can understand how controls are carried out in operational units such as blasting and loading, which are generators of particulate material. HS, involved in the agricultural sector further assured that the use of virtual reality to support mining projects would show the proposed execution of said projects would be undertaken in a more refreshing and convincing way.

IV. Discussion

Individual differences were found in aspects of the selected articles. This does not mean that they have a low methodological rigor [16], but these differences can make them more complementary. For example, the type of virtual reality technology used by Cranmer et al. [11] was different from that of Abulrub et al. [21], cinematographic (CVR), and immersive (IVR) respectively. Despite such differences, both results were positive, because these technologies are effective for their purpose, so it can be logically assumed that human-computer interaction is effective [22]. The interaction between virtual reality technology and the user has the most significant impact on those who have little or no experience with said technology [11]. Therefore, it is believed that virtual reality could be efficient in the communities lying within the sphere of influence of a mining project since most of them do not have any (previous) access to Information and Communication Technologies (ICT) [23], as highlighted in a 2018 study which stated that the use of virtual reality technology could be considered to be the main and most effective means of communication with the public due to its immersive capacity [7].

Due to the few articles found in the databases specified in the methodology, it is possible to argue that this research could be the first scoping review that refers to the use of virtual reality technology to generate a new opportunity for the social acceptance of mining projects. When performing an in-depth and exhaustive investigation into the databases mentioned in the methodology, very few articles were found related to the use of virtual reality for the social acceptance of mining projects. Indeed, no articles at all were found which were directly associated with the last variable. As a consequence, it was decided to analyze the experience with wind-energy projects, since both these and mining projects have a common problem: dealing with social acceptance [10] and reducing the gap in understanding and communication between the project and local communities [24]. Although it is possible to extract valuable information on the social acceptance of renewable energy (RE) projects, the appreciation is not the same since their operations do not have the same impact [25], For this reason, more experimental research is needed to know more precisely what the appreciation of the communities towards mining projects is and how HCI with virtual reality could reduce the understanding-communication gap [2, 21]. It is worth mentioning that Cranmer et al. [11], carried out his experimentation with a student community. Nevertheless, it was decided to include this article as part of the scoping review, since it shares the technological objective of this research and the results of the opinions were similar to those of the population from Massachusetts.

According to the research included for review and analysis, conventional 2D methods are still used currently to support projects [6], although it is stated that these traditional methods do not have enough interaction, nor the same understanding produced by experimenting with virtual reality technology [11,21], even though these technological methods are extraordinarily superior to traditional ones [1-3,6,11,15,21-22].

ICTs have been continuously improving over the years, and these tools can concretely and effectively support the teaching and learning process [26] that occurs when presenting a mining project to a specific population to achieve its acceptance and implementation. The use of ICT can be used by the personnel in charge of informing the public about the mining project, since these are flexible, accessible, affordable and without limitations in terms of time and space, so that the population with the mine’s sphere of influence can have a good understanding of the mine’s operations, activities and intentions [27].

The professionals' opinion provide us with support for the benefit acquired by using virtual reality technology as well as providing us with additional ideas to support mining projects, such as the idea proposed by (GP) on the creation of a visual model of wind management. In that way, the impact minimization plan [28] will practically be shown to residents, seeking to demonstrate that the benefit that the community will obtain by accepting the project will be higher than the cost of the impacts generated, as long as the corresponding legislation of the country where it would operate [10]. The idea of a professional in mining operations about the use of virtual reality technology, would surpass the understanding and understanding of conventional methodologies, coinciding with the opinion of (HS) an agricultural representative of a community within the sphere of a mining project, who believes it would improve understanding and, likewise, reduce the uncertainty of the local population [11,21,29], (HS) affirming that it would be a different and novel way of explaining the aspects of a mining project regarding its benefits, stages, operational processes and mitigation plan specified in the Environmental Impact Study. In this case, the farmer's point of view is highly important, since a social conflict between mining and agriculture is often generated.

The authors believe that the use of virtual reality can improve the planning of a mining project with the participation of the surrounding community, thereby ensuring a common benefit and reaching mutual agreement, as specified by Yu et.al [7], where public participation makes wind projects more acceptable.

V. Conclusion

The accessibility to the UCSM virtual library allowed us to do our research freely without any restrictions regarding different international databases, such as those mentioned in the methodology. Also, the opinion that was obtained from the interested parties was considered a strength. A limitation was the scarcity of existing research regarding the interaction of the local community with virtual reality in the context of social acceptance of mining projects. The current situation (SARS-CoV-2) is also considered as a difficulty to obtain more data or opinions from professionals and people close to a mining project.

We conclude that we have little scientific research information regarding the use of virtual reality in the interaction of neighboring communities for the social acceptance of mining projects.

Based on the experimental experiences from the selected articles, we conclude that immersive virtual reality (IVR) as well as cinematographic virtual reality (CVR) provides better communication and understanding between the user and the company in comparison to the traditional methods, improving the acceptance percentage of the proposed project.

The authors trust that this scoping review article will be the starting point to begin the experimental research and the future systematic reviews to contribute the use of virtual reality technology for the development of effective and interactive communication.

Acknowledgment

The authors declare that there is no conflict of interest. We thank the Universidad Católica de Santa María for providing us the easy access to scientific databases. We thank the professionals consulted in the mining sector: Eng. Milton Trujillo Espinoza, Eng. Giancarlo Pinto Guerra, and the farmer Helbert Samalvides for their important points of view on this research.

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