# Digital Learning Tools for Security Inductions in Mining Interns: A PLS-SEM Analysis

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***Abstract*—New pedagogical tools have been introduced in educational contexts in recent years. They have been shown to impact learning compared to conventional education strategies positively. Before implementing new learning tools, a study of technological acceptance is needed for its application to succeed. For this reason, the objective of this research was to measure the intention and acceptance of the use of new digital learning tools, such as mobile applications, holograms, interactive platforms, and virtual or augmented reality, through the Technology Acceptance Model 3 (TAM3) in safety on-board training inductions in a mining company. This measurement was based on the analysis of a survey carried out in Google Forms based on the Likert scale; the results were processed using the partial least squares technique in structural equation models (PLS-SEM), processed through SmartPLS 3. As a result, we got positive correlations between the instrument's variables and acceptance by the participants studied. The findings indicate that it is essential to consider the participants' opinions a priori to implementing new digital education tools for managerial decision-making. It was considering highlighting the teaching about safety in mining companies since this allows contributing to engineering education and protecting the most precious resource of any company, the human being.**

***Keywords—Technology acceptance model 3; PLS-SEM; SmartPLS; mining company; safety; safety inductions; safety talk; learning; education; teaching; technology; learning tools***

## I. INTRODUCTION

Technology is developing exponentially; it has covered fundamental aspects of human beings such as learning, focusing on eight topics: institutional environment, presence, pedagogy, technological elements, design, behaviors, affective elements, and learning outcomes [1]. It is worth mentioning that new technologies are gradually replacing the traditional approach to teaching [2] with a more social learning approach [3] as the number of publications about how the use of technology can be successful so that teachers can teach effectively, taking advantage of the opportunities of technological advances, generating an innovative learning environment based on play. Awakening students' interest in its use will better understand information [4][5]. However, research on technology-enhanced learning has been written chiefly by authors working in the educational field, representing approximately 70% of articles in all studies collected by a bibliometric analysis carried out in 2019; on the other hand, so only 9% were from articles written by authors who are working in engineering areas [6]. There is a lack of attention to applying digital learning tools in engineering, such as the training and inductions directed mainly through safety engineers in mining companies [7]. If the knowledge that they want to teach through training or induction is not transmitted adequately, the most valuable resource of companies, that is the human, would be more exposed to danger due to ignorance about the topics of safety, highlighting the great importance of education in the field of engineering.

The world's leading mining companies advise providing experiential learning in inductions and training through new interactive and immersive technologies such as podcasting, social media, interactive whiteboards, and virtual reality [8]. A study [9] examining the positive impact of the digital learning tool EPIC on 14,000 people found that the actor-based teaching application generates a more interactive and immersive pedagogical experience than a conventional classroom. It is also necessary to specify that a study [10] that used high fidelity simulation (HFS) identified that carrying out simulations more frequently and having the opportunity to "repeat" the experience would improve student learning. It is essential to mention that training, technical, and financial support requires the mining company's attention to implementing digital learning tools and achieving success in technology-supported education.

Technology acceptance model 3 (TAM3) was developed by Venkatesh [11]. It is essential to know the participants' opinions to analyze whether a new learning tool will be implemented and properly used, bringing considerable benefits [4] for students, teacher trainers, and the company where the pedagogical innovation would be applied. It has been researched with many different external variables in the literature [12]; it is an information systems theory that models how users come to accept and use technology.

The main objective of this work is to conduct a pilot test for practitioners and interns of mining companies in southern Peru to know their acceptance of digital learning tools using the TAM3.

## II. Related Work

Different works have been reviewed on the proposed theme that is shown below.

### A. Digital Learning Tools

Xu, Zhang, and Hou, in their paper [13], indicate that the traditional teaching methods such as 2D presentations, conferences, and workshops have been innovated by technological learning tools such as simulations, immersive virtual reality, augmented and mixed reality, mobile devices, online training platforms, and game engine techniques, among others. The importance of learning tools lies in improving teaching quality to meet external challenges and demands in education [14].

*1) Benefits for students and teacher trainers:* The use of digital learning tools would allow the student to obtain more virtual practical experience, being able to make mistakes since it is considered a safe place, and thus improve their performance and dexterity when facing an actual situation [10], solving problems with confidence and without anxiety. This benefit would enhance the student's emotional attitude, making them feel motivated and satisfied with learning in a non-traditional way [15]. In the paper by Kurniawan, Suharjito, Diana, and Witjaksono [15], it is worth mentioning that using these tools allows the student to assimilate the information better when dealing with complex subjects to understand. It also creates opportunities for discussion within the classroom since digital learning tools allow students to play an active role, unlike conventional classes, where they play a passive role [16].

Digital teaching tools provide the teacher with better pedagogical technologies than traditional methods to explain and make their students understand, thanks to these tools' interactivity capacity, making the learning process more attractive, fun, and collaborative [17]. These results encourage teachers to continue using innovative learning tools with their students [3], increasing teacher effectiveness, increasing the quality of education, reducing the burden of teaching complicated subjects, and improving student performance.

### B. Safety Culture and the Peruvian Regulation of Safety and Occupational Health in Mining

Mandhani, Nayak, and Parida [18] mention that safety is essential for all companies, especially mining companies, so the structure and culture of security are critical elements in safeguarding workers' lives.

The development of a safety culture in a mining company is essential to improve the rule-following behavior of employees to avoid the existence of incidents or accidents [19]. It is an indispensable medium for ensuring good performance in safety matters and significantly reducing accidents [20] [21]. According to Zhao, Zhao, Davidson, and Zuo [22], the economic loss due to occupational accidents represents approximately 8.5% of the project costs. For this reason, companies could be interested in providing safe working conditions to avoid expenses and safeguard human lives, where unique pedagogical campaigns such as training, inductions, health promotion, risk assessment, and the environment can be offered [23]. In Peru, mining companies are governed under the D.S. N ° 023-2017-EM [24] in terms of occupational health and safety, article 72 specifies the minimum number of hours of necessary induction (eight (8) hours during four (4) days in mining activities of high risk and eight (8) hours for two (2) days in lower risk mining activities). There, an entry to the mining operation must carry out very apart from the necessary induction; the number of courses may vary according to the area to enter. In the required induction, topics such as occupational health and safety policies of the company, Internal Regulation of Safety and Occupational Health, Traffic Rules, High-risk jobs, emergency plans in the mining company, and definitions of danger and risk must be learned effectively. Risk controls, among others. So, trainers must be committed to the quality of learning that students will receive to ensure compliance with the law and safeguard lives.

### C. Technological Acceptance Model (TAM3)

The TAM3 model was developed by Venkatesh [11] to determine the perceived usefulness and ease of use of the technology. The paper of Dönmez-Turan and Kir [25] indicates that the TAM3 was used to define the adoption of practitioners and interns working in mining companies in southern Peru to use new digital learning tools in safety inductions before entering the mine. As is shown in Table I, all the variables of the TAM3 used in the present investigation are defined. There is currently not enough research about implementing new digital learning tools in training and induction in mining companies. Since applying these tools in schools or universities is more studied, leaving aside the attention that industrial companies need in terms of education in security [26].

TABLE I. VARIABLES OF THE TAM3

| ***Variable*** | ***Conceptualization*** |
|---|---|
| Image (IMG) | The level at which an individual feels that technological innovation will increase their social status [26]. |
| Job Relevance (REL) | The degree to which a person believes that technological innovation can be applied to their work. |
| Output Quality (OUT) | The extent to which an individual believes that technological innovation can have a correct functionality in their work activities. |
| Result Demonstrability (RES) | The level at which a person thinks that technological innovation results can be observed and communicated. |
| Perceived Usefulness (PU) | The extent to which an individual perceives that technological innovation will improve their performance. |
| Computer Anxiety (CANX) | The degree to which an individual feels fear and insecurity when using technological innovations. |
| Computer Playfulness (CPLAY) | Level of enthusiasm that a person has when using technological innovation. |
| Computer Self-efficacy (CSE) | Measure which an individual feels capable of manipulating a technological innovation to carry out their activities. |
| Perceived Enjoyment (ENJ) | Level of enjoyment and satisfaction when using technological innovation. |

| *Variable* | *Conceptualization* |
|---|---|
| Objective Usability (OU) | The measure indicates how easy or difficult it will be to carry out a specific activity with technological innovation. |
| Perceptions of External Control (PEC) | The degree to which a person thinks there is adequate support to provide technical assistance for technological innovation. |
| Subjective Norm (SN) | Level of influence of one individual over another for the use of technological innovation. |
| Experience (EXP) | The extent to which an individual uses a technological innovation [11]. |
| Voluntariness (VOL) | The degree to which a person would use a technological innovation without being forced [26]. |
| Perceived Ease of Use (PEOU) | Measure how a person feels and how easy it will be to use technological innovation. |
| Behavioral Intention (BI) | Level of intention that an individual has to use technological innovation. |
| Use Behavior (USE) | Degree of permanence of a person in the face of technological innovation. |

## III. Methodology

### A. Participants

This study was directed to 46 practitioners and interns from different mining companies in Southern Peru. They are between 20 and 30 years old; the majority are between 22 and 25 years old, representing 85% of the sample. The survey was shared using Google Forms [27]; so that it could have reached each participant by overcoming any territorial limitations. Next, Table II shows the distribution of survey participants; they were divided between people who work in surface mining (open pit) or underground mining (sinkhole).

TABLE II. Distribution of Survey Participants

| *Type of field* | *Number of participants* | *Percentage* |
|---|---|---|
| Surface or open-pit mining | 42 | 91% |
| Underground or sinkhole mining | 4 | 9% |
| ***Total*** | 46 | 100% |

### B. TAM3 Measuring Instrument

The Technological Acceptance Model (TAM3) proposed by Venkatesh was used. A network of variables was developed for adoption, information technologies use and empirically tested in the proposed integrated model, focusing on the application of TAM3 both a priori and after implementing the technology. It was shown that TAM3 provides necessary help in making managerial decisions to implement new information technologies [11]. The TAM primarily analyzes the technological acceptance of innovative methods and tools in education. It was shown to be an excellent instrument for understanding the participants' intentions [16]. We decided to use the TAM3 over other essential tools in the measurement of technological acceptance, such as the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), since the latter includes variables such as age, gender, and price [28], whose parameters were considered not necessary for this research. A survey was conducted, taking into account the considerations of each TAM3 variable. They are defined in Table I. It was decided to use the Likert scale to establish a multiple-choice response range [29], having a range from 1 up to 7 points, where one meant "Strongly Disagree" and seven told, "Strongly Agree." Table III shows the questionnaire questions carried out on January 24, 2022.

TABLE III. Questionnaire Variables

| *Variable* | *Questionnaire* |
|---|---|
| Image (IMG) | Receiving induction classes using learning technologies raises the status of the mining company where I work. |
| Job Relevance (REL) | I feel that using learning technologies in induction classes will positively impact the various tasks related to my work. |
| Output Quality (OUT) | Learning technologies could have excellent results in my understanding of different induction topics. |
| Result Demonstrability (RES) | It could explain why learning technologies can be beneficial in understanding the information received in induction classes. |
| Perceived Usefulness (PU) | I think it is possible that the use of new learning technologies in my induction classes would improve my job performance. |
| Computer Anxiety (CANX) | I feel safe and comfortable using new learning technologies. |
| Computer Playfulness (CPLAY) | I am excited about using new learning technologies in my induction classes. |
| Computer Self-efficacy (CSE) | I have the necessary skills to use new learning technologies without difficulty in induction classes. |
| Perceived Enjoyment (ENJ) | It would be more fun to use new learning technologies in my induction classes at the mining company. |
| Objective Usability (OU) | I think the new learning technologies would be easy and dynamic to use. |
| Perceptions of External Control (PEC) | Having the necessary opportunities, knowledge, and resources, it would be easy for me to use new learning technologies. |
| Subjective Norm (SN) | I think induction teachers think that new learning technologies could be helpful. |
| Experience (EXP) | I have experience in the use of a technological learning system. |
| Voluntariness (VOL) | I think that I would voluntarily access my induction classes with new learning technologies. |
| Perceived Ease of Use (PEOU) | I believe that new learning technologies will be easy to use. |
| Behavioral Intention (BI) | If I have the opportunity to take induction classes using new learning technologies, I would be happy to try it. |
| Use Behavior (USE) | I would use new learning technologies frequently in my induction classes. |

### *C. Statistical Analysis with PLS-SEM*

The obtained results in Google Forms were exported to an Excel file, delimited by commas. Finally, the Smart-PLS 3 software was used to obtain, through the partial least squares technique in structural equation models (PLS-SEM), statistical data such as minimum and maximum responses for each variable, standard deviations, the correlation coefficient between variables, coefficient route, hypothesis t-test, frequencies, percentages, arithmetic means, and discriminant validity [30].

## IV. Results

In Table IV, we observed that all the arithmetic means of the responses of each variable of the Technological Acceptance Model exceeded the neutral state given in the Likert scale (4 - "Neither disagree nor agree"). There is also highlighted that all the questions had the highest level on the Likert scale had a maximum score (7 - "Totally agree"), so we can affirm that the surveyed participants have the intention and acceptance of the use of new technology learning tools to be implemented in safety induction classes before entering the mining company. The variable with the highest average response was (BI), with a value of 6,326 on the Likert scale; this was followed by (USE) with a value of 6,196 on the same scale, reaffirming the technological acceptance by participants for the implementation of mining educational tools. Likewise, these last two were the variables with the lowest standard deviation, having a value of 0.957 and 0.947, respectively, which means the homogeneity of the surveyed responses. The variables with the lowest average response were Experience (EXP) and Subjective Norm (SN), with values of 5.500 and 5.674, respectively; in the same way, these two variables had the highest standard deviation with values of 1.514 and 1.445, respectively, demonstrating the high dispersion of responses from each intern and practitioner, having a minimum of 1 and a maximum of 7 on the Likert scale. It should be mentioned [11] that these are two of the most critical variables of the TAM3.

The bilateral correlation of the TAM3 variables is presented in Table V. It shows all the correlations have a strong and positive correlation, indicating coherence between variables. In Table VI, we appreciated to determine if the constructs have discriminant validity, a statistical test used to demonstrate the multicollinearity of the proposed model; this should be addressed if certain variables exceed the threshold for possible multicollinearity (0.7) [31]. We explained that the model has good reliability and construct validity.

In Fig. 1, the standardized trajectory coefficients between all the variables performed by Venkatesh [26] and the substantial variance (R2) in each of its four endogenous variables [32] can be appreciated. It is essential to mention that only four hypotheses were validated for the study according to the t-test where the value of 1.96 has to be exceeded [33], these being the relationships between IMG -> PU, REL -> PU, SN -> IMG, and BI -> USE, 2.422, 2.174, 4.139 and 5.488 respectively.

TABLE IV. Descriptive Statistics

| | *Nº.* | *Mean* | *Min* | *Max* | *Standard deviation* |
|---|---|---|---|---|---|
| PU | 1 | 5.870 | 2 | 7 | 1.172 |
| IMG | 2 | 6.000 | 2 | 7 | 1.123 |
| REL | 3 | 5.783 | 2 | 7 | 1.301 |
| OUT | 4 | 6.000 | 3 | 7 | 1.043 |
| RES | 5 | 5.761 | 4 | 7 | 1.087 |
| PEOU | 6 | 5.804 | 2 | 7 | 1.262 |
| CANX | 7 | 6.022 | 4 | 7 | 1.011 |
| CPLAY | 8 | 6.065 | 3 | 7 | 1.009 |
| CSE | 9 | 6.152 | 4 | 7 | 1.042 |
| ENJ | 10 | 5.978 | 1 | 7 | 1.242 |
| OU | 11 | 5.848 | 3 | 7 | 1.179 |
| PEC | 12 | 6.152 | 4 | 7 | 0.999 |
| SN | 13 | 5.674 | 1 | 7 | 1.445 |
| EXP | 14 | 5.500 | 1 | 7 | 1.514 |
| VOL | 15 | 6.109 | 2 | 7 | 1.184 |
| BI | 16 | 6.326 | 4 | 7 | 0.957 |
| USE | 17 | 6.196 | 4 | 7 | 0.947 |

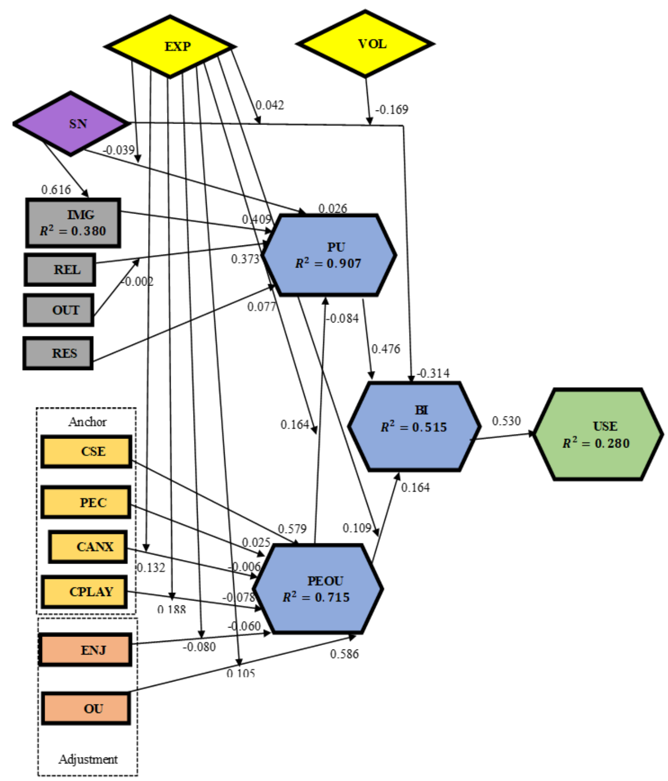


Fig. 1. Path Coefficients and Variances are Explained ($R^2$). Where, Image (IMG), Job Relevance (REL), Output Quality (OUT), Result Demonstrability (RES), Perceived Usefulness (PU), Computer Anxiety (CANX), Computer Playfulness (CPLAY), Computer Self-efficacy (CSE), Perceived Enjoyment (ENJ), objective Usability (OU), Perceptions of External Control (PEC), Subjective Norm (SN), Experience (EXP), Voluntariness (VOL), Perceived Ease of Use (PEOU), Behavioral Intention (BI).

TABLE V. BILATERAL CORRELATIONS

| | ***PU*** | ***IMG*** | ***REL*** | ***OUT*** | ***RES*** | ***PEOU*** | ***CANX*** | ***CPLAY*** | ***CSE*** | ***ENJ*** | ***OU*** | ***PEC*** | ***SN*** | ***EXP*** | ***VOL*** | ***BI*** | ***USE*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***PU*** | 1.000 | | | | | | | | | | | | | | | | |
| ***IMG*** | 0.892 | 1.000 | | | | | | | | | | | | | | | |
| ***REL*** | 0.851 | 0.729 | 1.000 | | | | | | | | | | | | | | |
| ***OUT*** | 0.729 | 0.706 | 0.561 | 1.000 | | | | | | | | | | | | | |
| ***RES*** | 0.709 | 0.588 | 0.778 | 0.595 | 1.000 | | | | | | | | | | | | |
| ***PEOU*** | 0.438 | 0.414 | 0.557 | 0.463 | 0.521 | 1.000 | | | | | | | | | | | |
| ***CANX*** | 0.498 | 0.460 | 0.417 | 0.475 | 0.638 | 0.515 | 1.000 | | | | | | | | | | |
| ***CPLAY*** | 0.761 | 0.768 | 0.558 | 0.765 | 0.490 | 0.386 | 0.489 | 1.000 | | | | | | | | | |
| ***CSE*** | 0.319 | 0.297 | 0.281 | 0.380 | 0.454 | 0.618 | 0.740 | 0.322 | 1.000 | | | | | | | | |
| ***ENJ*** | 0.730 | 0.748 | 0.603 | 0.537 | 0.592 | 0.427 | 0.381 | 0.712 | 0.322 | 1.000 | | | | | | | |
| ***OU*** | 0.678 | 0.542 | 0.673 | 0.548 | 0.650 | 0.711 | 0.477 | 0.575 | 0.514 | 0.710 | 1.000 | | | | | | |
| ***PEC*** | 0.648 | 0.542 | 0.644 | 0.668 | 0.534 | 0.541 | 0.147 | 0.529 | 0.291 | 0.581 | 0.647 | 1.000 | | | | | |
| ***SN*** | 0.655 | 0.616 | 0.633 | 0.476 | 0.504 | 0.418 | 0.258 | 0.671 | 0.177 | 0.710 | 0.468 | 0.561 | 1.000 | | | | |
| ***EXP*** | 0.245 | 0.268 | 0.221 | 0.124 | 0.376 | 0.347 | 0.533 | 0.278 | 0.710 | 0.399 | 0.481 | 0.165 | 0.253 | 1.000 | | | |
| ***VOL*** | 0.527 | 0.442 | 0.510 | 0.617 | 0.628 | 0.334 | 0.452 | 0.540 | 0.427 | 0.445 | 0.355 | 0.611 | 0.402 | 0.067 | 1.000 | | |
| ***BI*** | 0.600 | 0.445 | 0.703 | 0.436 | 0.639 | 0.431 | 0.600 | 0.451 | 0.386 | 0.335 | 0.526 | 0.448 | 0.328 | 0.218 | 0.564 | 1.000 | |
| ***USE*** | 0.767 | 0.675 | 0.688 | 0.573 | 0.573 | 0.360 | 0.314 | 0.761 | 0.256 | 0.688 | 0.669 | 0.658 | 0.682 | 0.235 | 0.582 | 0.530 | 1.000 |

TABLE VI. DISCRIMINANT VALIDITY

| | ***BI*** | ***CANX*** | ***CPLAY*** | ***CSE*** | ***ENJ*** | ***EXP*** | ***IMG*** | ***OU*** | ***OUT*** | ***PEC*** | ***PEOU*** | ***PU*** | ***REL*** | ***RES*** | ***SN*** | ***USE*** | ***VOL*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***BI*** | | | | | | | | | | | | | | | | | |
| ***CANX*** | 0.600 | | | | | | | | | | | | | | | | |
| ***CPLAY*** | 0.451 | 0.489 | | | | | | | | | | | | | | | |
| ***CSE*** | 0.386 | 0.740 | 0.322 | | | | | | | | | | | | | | |
| ***ENJ*** | 0.335 | 0.381 | 0.712 | 0.322 | | | | | | | | | | | | | |
| ***EXP*** | 0.218 | 0.533 | 0.278 | 0.710 | 0.399 | | | | | | | | | | | | |
| ***IMG*** | 0.445 | 0.460 | 0.768 | 0.297 | 0.748 | 0.268 | | | | | | | | | | | |
| ***OU*** | 0.526 | 0.477 | 0.575 | 0.514 | 0.710 | 0.481 | 0.542 | | | | | | | | | | |
| ***OUT*** | 0.436 | 0.475 | 0.765 | 0.380 | 0.537 | 0.124 | 0.706 | 0.548 | | | | | | | | | |
| ***PEC*** | 0.448 | 0.147 | 0.529 | 0.291 | 0.581 | 0.165 | 0.542 | 0.647 | 0.668 | | | | | | | | |
| ***PEOU*** | 0.431 | 0.515 | 0.386 | 0.618 | 0.427 | 0.347 | 0.414 | 0.711 | 0.463 | 0.541 | | | | | | | |
| ***PU*** | 0.600 | 0.498 | 0.761 | 0.319 | 0.730 | 0.245 | 0.892 | 0.678 | 0.729 | 0.648 | 0.438 | | | | | | |
| ***REL*** | 0.703 | 0.417 | 0.558 | 0.281 | 0.603 | 0.221 | 0.729 | 0.673 | 0.561 | 0.644 | 0.557 | 0.851 | | | | | |
| ***RES*** | 0.639 | 0.638 | 0.490 | 0.454 | 0.592 | 0.376 | 0.588 | 0.650 | 0.595 | 0.534 | 0.521 | 0.709 | 0.778 | | | | |
| ***SN*** | 0.328 | 0.258 | 0.671 | 0.177 | 0.710 | 0.253 | 0.616 | 0.468 | 0.476 | 0.561 | 0.418 | 0.655 | 0.633 | 0.504 | | | |
| ***USE*** | 0.530 | 0.314 | 0.761 | 0.256 | 0.688 | 0.235 | 0.675 | 0.669 | 0.573 | 0.658 | 0.360 | 0.767 | 0.688 | 0.573 | 0.682 | | |
| ***VOL*** | 0.564 | 0.452 | 0.540 | 0.427 | 0.445 | 0.067 | 0.442 | 0.355 | 0.617 | 0.611 | 0.334 | 0.527 | 0.510 | 0.628 | 0.402 | 0.582 | |

## V. DISCUSSION

Our results show that interns' and practitioners' technological acceptance were successful since they are willing to adapt to new digital learning tools, such as in research where a group of students intends to use new pedagogical strategies [4]. They could find the implementation and functionalities interesting, supporting their knowledge, as happened in a study that adopted an interactive web environment technology called MAgAdI at the University of the Basque Country [3]. It is intended to give the initiative to implement new digital learning tools in the mining industry, as recommended by a study where its findings foster crucial management decisions for the future implementation of information technologies [11]. It helps improve the academic performance effectively in the induction classes of the interns and practitioners before entering the mine, as is the case of a study that provided facilities of its results to school providers to use new innovative pedagogical methods [34]. It is necessary to highlight that the topics offered in the induction classes of the participants are both theoretical and practical so that the new learning tools could contribute to the improvement of their performance, as argued in a study where the Perception of Mining Engineering students, concluding that the use of technology in education is necessary to improve student performance [4]. Learning tools allow the user to be transferred to a virtual environment where it is allowed to make mistakes and learn through experience safely, as indicated in an investigation with simulated immersive learning platforms where their findings indicated that students could avoid taking risks to demonstrate their capabilities in a safe environment [10]. A study conducted in 2019 mentioned that virtual laboratories might have the same or better learning outcomes than t laboratories traditional [16], providing a unique learning experience [3], breaking the conventional scheme, and overlapping conventional learning [6], as we stated in the present study. In the present study, 46 pilot samples of different interns and practitioners of mining companies located in the macro-southern region of Peru were investigated to determine technological acceptance through TAM3, as was done in an article [35] where 44 respondents were studied, specifying that no there would be a problem in working with a small sample size since the results will be stable.

As we mentioned in the survey instructions, by new learning technologies, we mean: "virtual or augmented reality, holograms, interactive platforms, and mobile applications" according to the results had a positive impact on all TAM3 variables, as formulated by Venkatesh [35], especially in Use Behavior (USE) and Behavioral Intention (BI). The same situation occurred in a scientific production that shows that students' perception of virtual laboratories, simulators, interactive learning activities, and game-based learning positively influenced satisfaction, usefulness, and perceived ease of use [16]. An additional question was asked to the TAM3 to determine the preference of the studied participants towards a conventional class or a class with digital learning tools, where 89.13% of the total participants chose classes with innovative learning tools since these can keep employees focused positively and proactively as mentioned in a study conducted in Australia [23]. The participants in the presented studies rejected a conventional class, defined as a "lesson given by a teacher or trainer using 2D tools, such as slides, whiteboard, flipcharts, non-interactive videos"; it can generally cause stress and anxiety, reducing the value of learning [10] and being an obstacle to the adoption of a digital learning tool [25]. The present study used the partial least squares technique in structural equation models (PLS-SEM). Being very powerful and not having a minimum sample parameter gives us extra support for the validity of the results, as Said Al-Gahtani comments [32]. SmartPLS 3 software analyzed these data; it was used from the same firm by different studies associated with TAM evaluation [36] [37]. The results of the discriminant variance correlations mostly exceed the threshold of 0.7, confirming the construct's validity and the trajectory correlations of the present study. These were positive and strong, as evidenced by studies conducted between 2015 and 2021 [31][38]. The results also indicate that IMG significantly influences PU, as happens in a study carried out in Saudi Arabia, where it is specified that social influence processes were shown to affect perceived profit. On the other hand, the same study found that the instrumental cognitive function positively impacts Perceived Utility, as this article [32] did when validating the REL -> PU hypotheses.

It has been considered to use all external variables of Technology Acceptance Model 3 because they are considered more relevant concerning Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), one of the essential acceptance models TAM3 [1]. The TAM3 was considered, unlike UTAUT2, because the external variables of the TAM3 facilitate the intention and maintain voluntariness [24], unlike UTAUT2, which predominates individual conditions such as gender, age, price value.

## VI. Conclusion

Safety is necessary to provide qualified education to collaborators to increase their effectiveness by voluntary rules compliance, preserving the human resource that is the most crucial element of the companies, and saving accident expenses. It can be achieved using more effective pedagogical tools than traditional ones. However, it is essential to know if staff are willing to accept new learning technologies such as virtual or augmented reality, holograms, interactive platforms, and mobile applications. Before joining a mining company, interns and practitioners intend to use new technological learning tools in induction classes. We recommended expanding the sample of hired workers for future research work since they receive constant safety talks specified by the D.S. N ° 023-2017-EM, since integral management of the safety culture is being promoted, that goes from the highest rank to the lowest level; consequently, this would cause a change in attitude in the company members, making them take care of each other. We recommend mining and industrial companies implement new digital learning tools to train human resources and improve the development of their skills in occupational safety and health. There is limited research on technological acceptance to help management decision-making. It is necessary to imply that studies on the implementation of pedagogical technologies should not be centralized only in schools or universities, mining, and industrial companies where education can save lives, so we recommended developing scientific production in that theme and domain.

## References

[1] J. W. M. Lai and M. Bower, "How is the use of technology in education evaluated? A systematic review," Comput. Educ., vol. 133, 2019, doi: 10.1016/j.compedu.2019.01.010.

[2] S. O'Connor and T. Andrews, "Smartphones and mobile applications (apps) in clinical nursing education: A student perspective," Nurse Educ. Today, vol. 69, 2018, doi: 10.1016/j.nedt.2018.07.013.

[3] A. Álvarez, M. Martín, I. Fernández-Castro, and M. Urretavizcaya, "Blending traditional teaching methods with learning environments: Experience, cyclical evaluation process and impact with MAgAdI," Comput. Educ., vol. 68, 2013, doi: 10.1016/j.compedu.2013.05.006.

[4] P. López, J. Rodríguez, A. Acosta, and M. Berrios, "Analysis from the student perspective on the implementation of learning technologies in mining engineering," in CEUR Workshop Proceedings, 2019, vol. 2555.

[5] M. Kangas, P. Siklander, J. Randolph, and H. Ruokamo, "Teachers' engagement and students' satisfaction with a playful learning environment," Teach. Teach. Educ., vol. 63, 2017, doi: 10.1016/j.tate.2016.12.018.

[6] C. wen Shen and J. tsung Ho, "Technology-enhanced learning in higher education: A bibliometric analysis with latent semantic approach," Comput. Human Behav., vol. 104, 2020, doi: 10.1016/j.chb.2019.106177.

[7] A. Adyatama, D. H. Syaifullah, and B. N. Moch, "Evaluating the role of cognitive factors on hauling workplace accidents: Study case at Central Borneo coal mining company," in AIP Conference Proceedings, 2020, vol. 2227, doi: 10.1063/5.0007247.

[8] J. Zhang, J. Fu, H. Hao, G. Fu, F. Nie, and W. Zhang, "Root causes of coal mine accidents: Characteristics of safety culture deficiencies based on accident statistics," Process Saf. Environ. Prot., vol. 136, 2020, doi: 10.1016/j.psep.2020.01.024.

[9] E. J. Harvey, J. A. Pinder, R. A. Haslam, A. R. J. Dainty, and A. G. Gibb, "The use of actor-based immersive health and safety inductions: Lessons from the Thames Tideway Tunnel megaproject," Appl. Ergon., vol. 82, 2020, doi: 10.1016/j.apergo.2019.102955.

[10] H. MacLean, K. J. Janzen, and S. Angus, "Lived Experience in Simulation: Student Perspectives of Learning From Two Lenses," Clin. Simul. Nurs., vol. 31, 2019, doi: 10.1016/j.ecns.2019.03.004.

[11] V. Venkatesh and H. Bala, "Technology acceptance model 3 and a research agenda on interventions," Decis. Sci., vol. 39, no. 2, 2008, doi: 10.1111/j.1540-5915.2008.00192.x.

[12] A. Donmez-Turan and M. T. Odabas, "Evaluating Technology Acceptance Model on the User Resistance Perspective: A Meta-analytic Approach," in Communications in Computer and Information Science, 2022, vol. 1534 CCIS, doi: 10.1007/978-3-030-96040-7_59.

[13] S. Xu, M. Zhang, and L. Hou, "Formulating a learner model for evaluating construction workers' learning ability during safety training," Saf. Sci., vol. 116, 2019, doi: 10.1016/j.ssci.2019.03.002.

[14] Q. Liu, S. Geertshuis, and R. Grainger, "Understanding academics' adoption of learning technologies: A systematic review," Comput. Educ., vol. 151, 2020, doi: 10.1016/j.compedu.2020.103857.

[15] J. M. Zydney and Z. Warner, "Mobile apps for science learning: Review of research," Comput. Educ., vol. 94, 2016, doi: 10.1016/j.compedu.2015.11.001.

[16] R. Estriegana, J. A. Medina-Merodio, and R. Barchino, "Student acceptance of virtual laboratory and practical work: An extension of the technology acceptance model," Comput. Educ., vol. 135, 2019, doi: 10.1016/j.compedu.2019.02.010.

[17] M. H. Kurniawan, Suharjito, Diana, and G. Witjaksono, "Human Anatomy Learning Systems Using Augmented Reality on Mobile Application," in Procedia Computer Science, 2018, vol. 135, doi: 10.1016/j.procs.2018.08.152.

[18] J. Mandhani, J. K. Nayak, and M. Parida, "Interrelationships among service quality factors of Metro Rail Transit System: An integrated Bayesian networks and PLS-SEM approach," Transp. Res. Part A Policy Pract., vol. 140, 2020, doi: 10.1016/j.tra.2020.08.014.

[19] E. Stemn, C. Bofinger, D. Cliff, and M. E. Hassall, "Examining the relationship between safety culture maturity and safety performance of the mining industry," Saf. Sci., vol. 113, 2019, doi: 10.1016/j.ssci.2018.12.008.

[20] H. Lu and H. Chen, "Does a people-oriented safety culture strengthen miners' rule-following behavior? The role of mine supplies-miners' needs congruence," Saf. Sci., vol. 76, 2015, doi: 10.1016/j.ssci.2015.02.018.

[21] M. Rubin, A. Giacomini, R. Allen, R. Turner, and B. Kelly, "Identifying safety culture and safety climate variables that predict reported risk-taking among Australian coal miners: An exploratory longitudinal study," Saf. Sci., vol. 123, 2020, doi: 10.1016/j.ssci.2019.104564.

[22] Z. Y. Zhao, X. J. Zhao, K. Davidson, and J. Zuo, "A corporate social responsibility indicator system for construction enterprises," J. Clean. Prod., vol. 29–30, 2012, doi: 10.1016/j.jclepro.2011.12.036.

[23] A. M. Vecchio-Sadus and S. Griffiths, "Marketing strategies for enhancing safety culture," Saf. Sci., vol. 42, no. 7, 2004, doi: 10.1016/j.ssci.2003.11.001.

[24] D.S. N° 023-2017-EM, “Reglamento de Seguridad y Salud Ocupacional en Minería D.No 023-2017-EM,” D. Of. El Peru., 2017.

[25] A. Dönmez-Turan and M. Kir, "User anxiety as an external variable of technology acceptance model: A meta-analytic study," in Procedia Computer Science, 2019, vol. 158, doi: 10.1016/j.procs.2019.09.107.

[26] M. Loosemore and N. Malouf, "Safety training and positive safety attitude formation in the Australian construction industry," Saf. Sci., vol. 113, 2019, doi: 10.1016/j.ssci.2018.11.029.

[27] T. L. Wiemken, S. P. Furmanek, W. A. Mattingly, J. Haas, J. A. Ramirez, and R. M. Carrico, "Googling your hand hygiene data: Using Google Forms, Google Sheets, and R to collect and automate analysis of hand hygiene compliance monitoring," Am. J. Infect. Control, vol. 46, no. 6, 2018, doi: 10.1016/j.ajic.2018.01.010.

[28] V. Venkatesh, J. Y. L. Thong, and X. Xu, "Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology," MIS Q. Manag. Inf. Syst., vol. 36, no. 1, 2012, doi: 10.2307/41410412.

[29] S. E. Harpe, "How to analyze Likert and other rating scale data," Currents in Pharmacy Teaching and Learning, vol. 7, no. 6. 2015, doi: 10.1016/j.cptl.2015.08.001.

[30] M. Martínez Ávila and E. Fierro Moreno, “Aplicación de la técnica PLS-SEM en la gestión del conocimiento: un enfoque técnico práctico / Application of the PLS-SEM technique in Knowledge Management: a practical technical approach,” RIDE Rev. Iberoam. para la Investig. y el Desarro. Educ., vol. 8, no. 16, 2018, doi: 10.23913/ride.v8i16.336.

[31] K. M. S. Faqih and M. I. R. M. Jaradat, "Assessing the moderating effect of gender differences and individualism-collectivism at individual-level on the adoption of mobile commerce technology: TAM3 perspective," J. Retail. Consum. Serv., vol. 22, 2015, doi: 10.1016/j.jretconser.2014.09.006.

[32] S. S. Al-Gahtani, "Empirical investigation of e-learning acceptance and assimilation: A structural equation model," Appl. Comput. Informatics, vol. 12, no. 1, 2016, doi: 10.1016/j.aci.2014.09.001.

[33] S. A. Kamal, M. Shafiq, and P. Kakria, "Investigating acceptance of telemedicine services through an extended technology acceptance model (TAM)," Technol. Soc., vol. 60, 2020, doi: 10.1016/j.techsoc.2019.101212.

[34] D. R. Compeau and C. A. Higgins, "Computer self-efficacy: Development of a measure and initial test," MIS Q. Manag. Inf. Syst., vol. 19, no. 2, 1995, doi: 10.2307/249688.

[35] V. Venkatesh and F. D. Davis, "Theoretical extension of the Technology Acceptance Model: Four longitudinal field studies," Manage. Sci., vol. 46, no. 2, 2000, doi: 10.1287/mnsc.46.2.186.11926.

[36] P. R. Schulman, "Organizational structure and safety culture: Conceptual and practical challenges," Saf. Sci., vol. 126, 2020, doi: 10.1016/j.ssci.2020.104669.

[37] M. Ramkumar, T. Schoenherr, S. M. Wagner, and M. Jenamani, "Q-TAM: A quality technology acceptance model for predicting organizational buyers' continuance intentions for e-procurement services," Int. J. Prod. Econ., vol. 216, 2019, doi: 10.1016/j.ijpe.2019.06.003.

[38] J. C. Sánchez-Prieto, S. Olmos-Migueláñez, and F. J. García-Peñalvo, “MLearning and pre-service teachers: An assessment of the behavioral intention using an expanded TAM model,” Comput. Human Behav., vol. 72, 2017, doi: 10.1016/j.chb.2016.09.061.