***MATTER: International Journal of Science and Technology***
***ISSN 2454-5880***

*Chou et al., 2023*

*Volume 9, pp. 127-141*

*Received: 24th August 2023*

*Revised: 09th October 2023, 26th October 2023*

*Accepted: 27th December 2023*

*Date of Publication: 30th December 2023*

*DOI- https://doi.org/10.20319/mijst.2023.9.127141*

*This paper can be cited as: Chou, C. M., Shen, T. C., Shen, T. C., Shen, C. H. & Liu, T. L. (2023). Learning Effectiveness among Tertiary Students using Augmented Reality (AR)-Based for Adapting to Industry 4.0. MATTER: International Journal of Science and Technology, 9, 127-141.*



# LEARNING EFFECTIVENESS AMONG TERTIARY STUDENTS USING AUGMENTED REALITY (AR)-BASED FOR ADAPTING TO INDUSTRY 4.0

**Chun-Mei Chou**
*Professor, Institute of Vocational and Technological Education, National Yunlin University of Science and Technology ,Yunlin, Taiwan, Republic of China*
*choucm@yuntech.edu.tw*

**Tsu-Chi Shen**
*Postgraduate, Graduate of Creative Design, National Yunlin University of Science & Technology,* Yunlin , *Taiwan , Republic of China*
*B10836004@yuntech.edu.tw*

**Tsu-Chuan Shen**
*Postgraduate, Graduate Institute of Information Engineering, National Yunlin University of Science & Technology, Yunlin , Taiwan , Republic of China*
*whencharlis@gmail.com*

**Chien-Hua Shen**
*Professsor, Department of Business Administration, Transworld Institute of Technology, Yunlin, Taiwan, Republic of China*
*shen17@ms51.hinet.net*

**Tzu-Ling Liu**
*Postgraduate, Graduate Institute of Visual Communication Design, National Yunlin University of Science and Technology, Yunlin , Taiwan, Republic of China*

## Abstract

*This study aimed to explore the correlation among AR-based learning effectiveness (ARLE), AR learning beliefs (ARLB), creative learning self-efficacy (CLS), and AR learning motivation (ARLM) of tertiary students in Taiwan. Participants had 378 tertiary students who from 15 school, and used path analysis model of the structural equation model (SEM) based on the questionnaire survey. The results show that there is a significant positive correlation between the AR Learning Beliefs (ARLB) and AR Learning Motivation (ARLM) of tertiary student. It is found that higher correlation between ARLB, ARLM and Creative Learning Self-Efficacy (CLS). There was a significant positive correlation between ARLE and ARLB, and can effectively explain ARLE. This study confirms that CLS is an important factor and an impact mediating factor between ARLB and ARLM. In addition, CLS can also influence ARLE through ARLM.*

**Keywords**

AR-Based Learning Effectiveness (ARLE), Creative Learning Self-Efficacy (CLS), AR Learning Motivation (ARLM), AR Learning Beliefs (ARLB)

## 1. Introduction

In response to the rapid changes in the social and industrial sectors. Taiwan's higher education promotes the Industry 4.0 program policy and technical re-engineering program, and subsidizes the AR-based learning of vocational schools to foster AR-based learning integration capabilities to enhance student employment (Atici-ulusu et al., 2021; Al- Zou'bi, 2021; Nita ET AL., 2021). Industry 4.0 will bring together talents to jointly promote the industrial production chain created by the Internet of Things (IoTs). AR-based talents can adapt to this trend, and the education of the vocational system must be prepared in response to changes and cultivate talents with AR-based learning capabilities (Belda-Medina, 2022; Bölek et al., 2021; Enkel et al., 2020; Globe Newswire, 2022; Rupmik & Avsec, 2020).

The AR-based learning department encourages different professions to learn from and communicate with each other in the face of common problems and challenges. It is important to

actively transform professional common sense into knowledge in other people's lives and play the social communication function. In response to Industry 4.0, it is advisable to actively establish a systematic AR-based learning education model (Belda-Medina & Calvo-Ferrer, 2022; Bellamy et al., 2022; Fam et al., 2020; Rupmik & Avsec, 2021). AR-based learning education fosters "problem-oriented" talent development and strives to develop social, humanities, and science skills. Through AR-based learning platforms and deepening the interdisciplinary cooperation of individual students, it has the ability to establish trans-cognition and the practice of AR-based learning and communication (Buchner & Zumbach, 2020; Evans, 2015; Kuo et al., 2019). Factors affecting students' ARLE include personal factors and organizational factors. However, in the AR-based learning of creative learning environments, there is a lack of research literature. The primary goal of this research is to determine the effectiveness of AR-based learning on students. A hypothetical model to understand the personal factors that influence the overall learning of students across domains (Cai et al., 2021; Chaudhry, & Kazim, 2022; Chou et al., 2022; Kuo et al., 2019; Schwab, 2019).

### 1.1. AR-Based Learning

Some Studies from the past have shown that research on personal factors is mostly directed at learners' personality traits or cognitive processes (Fernández-Batanero et al., 2022; Schwab, 2019; Vally et al., 2019). However, in addition to the individual's personality traits and ability factors that will affect the student's AR-based learning performance, another question worth exploring is what factors will lead to the generation of individual ICT-domain behavior in the student's ARLM and CLS (Gargrish et al., 2021; Garzón & Acevedo, 2019; Schwab, 2019; Vally et al., 2019). Efficacy expectation refers to the main determinant of an individual's goal-setting, activity choice, and willingness to expend effort in individual action. The effect of individual subjective self-evaluation on individual behavioral performance is called self-efficacy. "Domain-relevant skills" are an important element of creativity. Therefore, AR-based knowledge or creative learning motivation is an important factor (Garzón et al., 2019; Oral, 2017; Schwab, 2019; Vally et al., 2019).

As for students, if the knowledge of learning is easy to obtain and internalize as a part of itself, not only can it improve their self-efficacy of creative learning, but also help their ARLE. The improvement of self-efficacy through creative learning indirectly affects the effectiveness of AR-based learning. Therefore, exploring the relationship between ARLB, ARLM, CLS, and

ARLE, and thus improving the learning quality of AR-based learning areas is also one of the aims of this research (Chang et al., 2019; Hoffman et al., 2016).

### 1.2. Creative Learning Self-Efficacy

In addition, CLS may be an important factor in predicting the effectiveness of AR-based learning, and ARLM is an important factor in ARLE. Some researchers point out that ARLM encourages individuals to engage in creative performance and to continue their creative performance (Collado-Ruano et al., 2019; Cayirdag, 2017). Because individuals encounter many setbacks and obstacles in the process of engaging in creative behavior, they not only need long-term investment but may also be affected by the external environment. If there is no strong motivation, it is difficult for individuals to continue their creative displays. It can be seen that when students engage in ARLE and creative learning behaviors, their ARLM also has considerable influence (Brazile et al., 2018; Desombre et al., 2019).

According to the research on creative self-efficacy, an individual's motivation, cognition, and belief in creativity form creative self-efficacy, and that individual's confidence and attitude toward his creative performance will affect his creative behavior. Scholars believe that the improvement of creative self-efficacy enables individuals to produce more AR-based learning and creativity behaviors, and is also an important factor in promoting the development of individual creativity (Alzoubi et al., 2016; Torsney et al., 2019). Therefore, this study regards CLS as a discussion. One of the personal factors that make students learn about AR-based learning (Santos & Mognon, 2016; Torsney et al., 2019; Vally et al., 2019).

In summary, this study explores whether ARLB has an impact on the effectiveness of creative learning in relation to student AR-based learning. In addition, the inclusion of CLS influences creative learning motivation in ARLE. Finally, it will be analyzed whether the structural model of ARLE factors is relevant, and can be used as a reference for the study of AR-based learning. The purpose of this study is:

(1) Explore the prediction of AR learning beliefs (ARLB) and creative learning self-efficacy (CLS).
(2) Explore the prediction of creative learning self-efficacy (CLS) and AR-based learning motivation (ARLM).
(3) Analyze the correlation between the potential variable path and the structural model.

# 2. Methodology

## 2.1. Research Method and Subjects

This research department adopts the technical vocational school in Taiwan as the mother body, and is divided into the north, middle and south regions of Taiwan. According to the willingness to conduct consultation with each school, the stratified randomness of the sampling schools will be improved, and finally 15 schools will be obtained of 8 departments of the University of Science and Technology, 5 technical colleges and 2 specialist colleges. There are 450 questionnaires were responded. The recovery rate was 84% and the effective sample was 378. The average age is 22.4. Overall, the sample structure is consistent with the characteristics of the student group of the vocational school.

## 2.2. Research Tool and Data Analysis

*2.2.1. AR-Based Learning Belief (ARLB) Scale*

This research scale uses constructive factor analysis for exploratory factor analysis. The factor extraction method used is "Principal Axis Factoring" and the factor axis used Orthogonal Varimax. The ARLB scale consists of nine factors: taste for new change, enjoy at work, emotional intelligence, multi-angle reasoning, independent thinking, problem solving, deliberate interaction, broad interest and imagination. The Cronbach's α value of each factor is .65-.91, and the Cronbach's α value of the total scale is .95. The cumulative explanatory variable of the factor is 55.43%, indicating that this scale is suitable for the measurement of the student.

*2.2.2. AR Learning Motivation (ARLM) Scale*

The ARLM scale is compiled by 16 questions. This measure uses the principal component method and the skewed axis to analyze the factors. The results show that "accepting learning goal challenge" and "learning of welfare experience" can explain 78% of the change. The Cronbach's α value of the "accept challenge" subscale is .93, and the "Crowbach's α value" of the "future experience" is .91.

*2.2.3. Creative Learning Self-Efficacy (CLS) Scale*

The creative learning self-efficacy scale is measured and the full scale have good internal consistency reliability. The Cronbach's α value of each factor is between .74 and .86, and the full scale is .89. The retest reliability is .8, which achieves a highly significant positive correlation, indicating that the CLS has a fairly good retest reliability. In terms of validity, the

results of factor analysis found that the “CLS energy scale” consists of three factors: positive affirmation, creative belief, and tolerance of ambiguity. It with good construct validity and there are significant differences in aspects.

*2.2.4. AR-Based Learning Effectiveness (ARLE) Scale*

This scale is a knowledge integration behavior scale developed that items are mainly corrected by reference to the scales developed by various scholars. The scale has good internal consistency of knowledge integration, integration initiative and creative behavior subscale and full scale. The Cronbach’s α value of each factor is between .84 and .96, and the full scale is .91.

### 2.3. Data Analysis

This research used statistical software package (SPSS) for data analysis. Statistical analysis methods include descriptive statistics, Pearson correlation and multi-level regression analysis. Finally, the path analysis model of Structural Equation Modeling (SEM) is used to verify the hypothetical architecture of this study. The potential path models were analyzed by LISREL. The alpha level of the study results was set to .05

## 3. Results

The results of the study in Table 1 for ARLB for CLS and students’ ARLE are found to be relevant. The factors of ARLB are significantly positively correlated with CLS. ARLB can explain 55.6% of the changes in CLS ($F$=51.84, p< .001). Among the various factors of ARLB, "solving problems" has the best explanatory power, and its Beta system reaches .29, indicating that the higher the "problem-solving" of students, the higher their "CLS". The second is "try new and change", and the Beta system is .19, which means that if the student's "taste to change" tendency is higher, the higher the "CLS". In addition, “imagining” (β = .17), “enjoy at work" (β = .12) and "deliberate interaction" (β = .12) also have a statistical interpretation of CLS; The rest of the face is not.

The table 2 was self-efficacy of creative learning that multivariate regression analysis of ARLMs. The results show that the three factors of CLS are put into regression analysis. The effect of CLS on ARLM can be explained. 56.8% of the amount of change (F = 115.11, p < .001). The researchers further tested the three factors of CLS, and the results of the estimation pointed out that "positive affirmation" (β = .62, p < .001) and "tolerance of ambiguity" (β =.17, p< .001) has a

statistical power to explain that the higher the performance of the student's "positive affirmation" and "tolerance of ambiguity", the higher the ARLM.

**Table 1**: *Multi-Level Regression Analysis of ARLB on CLS*

| Predictive variable r | r | Beta | *t*-test |
|---|---|---|---|
| **AR-based learning belief** | | | |
| **Try new changes** | 0.64* | .19 | 3.45* |
| **Enjoy at work** | 0.58* | .12 | 2.75* |
| **Emotional intelligence** | 0.61* | .08 | 1.61 |
| **Multi-angle reasoning** | 0.50* | -.08 | -1.67 |
| **Independent thinking** | 0.44* | -.05 | -1.16 |
| **Solving problem** | 0.67* | .29 | 4.63* |
| **Deliberate interaction** | 0.57* | .12 | 2.47* |
| **Broad interest** | 0.50* | .02 | .35 |
| **Imagining** | 0.60* | .17 | 3.46* |
| **R2** | .005 | .55 | |
| **Adjusted R2** | -.001 F=.87 | .54 F=51.84* | |
| **ΔR2** | .540 | | |

*p< .05

*(Source: Self/Authors' Own Illustration)*

**Table 2:** *Multivariate Regression Analysis of CLS on ARLM*

| Predictive variable | r | Beta | *t*-test |
|---|---|---|---|
| **CLS** | | | |
| **Positive affirmation** | 0.74* | 0.62 | 16.19* |
| **Creative belief** | 0.32* | 0.05 | 1.71 |
| **Tolerance of ambiguity** | 0.56* | 0.17 | 4.47* |
| **R2** | 0.001 | 0.57 | |
| **Adjusted R2** | -0.01 F=.14 | 0.56 F=115.11* | |
| **ΔR2** | | 0.58 | |

*p< .05

*(Source: Self/Authors' Own Illustration)*

The Table 3 shows the relationship between the factors affecting ARLE. The matrix is based on the path analysis with latent variable, and the overall model of ARLE proposed by this study is tested. The structural path analysis of structural equations with potential variables described by LISREL to analyze whether the structural patterns of ARLE factors are relevant and it can be used as a reference for students' ARLE. In the structural equation mode path analysis, the indicator variables of each potential variable, the AR-based learning belief of the external variable (ξ1) to taste new changes (X1), enjoy at work (X2) Emotional intelligence (X3), multi-angle reasoning (X4), independent thinking (X5), problem solving (X6), deliberate interaction (X7), board interest (X8) and imaginary imagination (X9) are indicators. In terms of internal variable potential variables, AR-based learning effectiveness (η 1) uses knowledge integration (Y1), integration initiative (Y2) and creative behavior (Y3) as indicators; CLS (η 2) are used as indicator variables. According to the results of factor analysis, positive affirmation (Y4), creative belief (Y5) and tolerance of ambiguity (Y6) are used as indicators. The ARLM (η 3) is based on the acceptance the challenge (Y7) and Welfare experience (Y8).

**Table 3:** *The Relationship between the Factors Influencing the Effectiveness of AR-Based Learning*

| **Related coefficient** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Knowledge integration | 1.0 | | | | | | | | | | | | | | | | | | |
| 2. Integration initiative | .63 | 1.0 | | | | | | | | | | | | | | | | | |
| 3. Creative behavior | .65 | .60 | 1.0 | | | | | | | | | | | | | | | | |
| 4. Positive affirmation | .68 | .59 | .72 | 1.0 | | | | | | | | | | | | | | | |
| 5. Creative belief | .28 | .25 | .29 | .37 | 1.0 | | | | | | | | | | | | | | |
| 6. Tolerance of ambiguity | .57 | .53 | .54 | .62 | .24 | 1.0 | | | | | | | | | | | | | |
| 7. Accept the challeng | .63 | .55 | .51 | .68 | .26 | .54 | 1.0 | | | | | | | | | | | | |
| 8. Welfare experience | .46 | .45 | .49 | .62 | .31 | .45 | .56 | 1.0 | | | | | | | | | | | |
| 9. Taste new changes | .71 | .55 | .57 | .67 | .28 | .53 | .80 | .56 | 1.0 | | | | | | | | | | |
| 10. Enjoy at work | .47 | .43 | .54 | .58 | .31 | .45 | .53 | .64 | .59 | 1.0 | | | | | | | | | |
| 11. Emotional intelligence | .54 | .52 | .51 | .64 | .29 | .45 | .62 | .58 | .68 | .64 | 1.0 | | | | | | | | |
| 12. Multi-angle reasoning | .50 | .43 | .48 | .52 | .21 | .45 | .58 | .41 | .64 | .55 | .63 | 1.0 | | | | | | | |
| 13. independent thinking | .48 | .42 | .41 | .50 | .09 | .47 | .54 | .38 | .59 | .49 | .55 | .60 | 1.0 | | | | | | |
| 14. Master the key | .63 | .56 | .59 | .71 | .30 | .52 | .70 | .58 | .76 | .66 | .75 | .73 | .68 | 1.0 | | | | | |
| 15. Deliberate interaction | .42 | .43 | .53 | .59 | .29 | .43 | .55 | .54 | .60 | .63 | .66 | .63 | .46 | .67 | 1.0 | | | | |
| 16. Wide interest | .48 | .35 | .44 | .53 | .25 | .36 | .55 | .41 | .61 | .51 | .51 | .47 | .42 | .54 | .53 | 1.0 | | | |
| 17. Imagining | .68 | .47 | .54 | .65 | .23 | .51 | .61 | .45 | .70 | .56 | .59 | .53 | .50 | .64 | .49 | .65 | 1.0 | | |
| 18. Knowledge internalization | .44 | .45 | .37 | .46 | .12 | .36 | .39 | .33 | .37 | .33 | .33 | .22 | .25 | .37 | .29 | .28 | .34 | 1.0 | |
| 19. Knowledge acquisition | .28 | .29 | .24 | .31 | .02 | .20 | .26 | .18 | .24 | .25 | .22 | .11 | .17 | .20 | .15 | .17 | .22 | .50 | 1.0 |

**Note:** *The correlation of the above factors is up to the significant level of $p < .05$*

*(Source: Self/Authors' Own Illustration)*

This table is compiled according to the t test value and the fully standardized solution obtained from the revised model. As can be seen from Table 4, the overall effect of ARLB on ARLE is .72 ($p < .001$); the overall effect on creative learning self-efficacy is .75 ($p < .001$); For ARLM, the overall effect is .96 ($p < .001$). The overall effect on CLS was .23 ($p < .001$); the overall effect on ARLM was .09 ($p < .001$). The overall effect of CLS on ARLE was .71 ($p < .001$); the overall effect on ARLM was .40 ($p < .001$). The overall effect of ARLM on ARLE is .29 ($p < .05$). The results show that the overall effect of all potential variables is significant. According to the overall model of ARLE proposed by this research, the overall fitness test results of this model have good depreciation, but due to the unusual depreciation of the impact of ARLB on ARLE. This path relationship is removed. After the model modification results, it is assumed that the model has a good fit with the observation data. The results of the variables and the results of the direct and indirect effects show that the problem relationships raised in this study are supported. **Table 4:** Potential Variable Path Analysis Structure Model

| **Independent variables** | **η1 AR-based learning belief** | | **η2 creative leaning self-efficacy** | | **η3 AR learning motivation** | |
|---|---|---|---|---|---|---|
| | **Effect** | ***t*** | **Effect** | ***t*** | **Effect** | ***t*** |
| **ξ*1*AR-based learning belief** | | | | | | |
| **Direct effect** | - | - | .75 | 18.55*** | .66 | 8.96*** |
| **Indirect effect** | .72 | 16.33*** | - | - | .30 | 5.30*** |
| **overall effect** | .72 | 16.33*** | .75 | 18.55*** | .96 | 22.31*** |
| **η*2* creative leaning self-efficacy** | | | | | | |
| **Direct effect** | .60 | 4.35*** | | | .40 | 5.45*** |
| **Indirect effect** | .12 | 2.20*** | | | - | - |
| **overall effect** | .71 | 7.38*** | | | .40 | 5.45*** |
| **η*3* AR learning motivation** | | | | | | |
| **Direct effect** | .29 | 2.45* | | | | |
| **Indirect effect** | - | - | | | | |
| **overall effect** | .29 | 2.45* | | | | |

*(Source: Self/Authors' Own Illustration)*

## 4. Discussion and Conclusion

The study's results found that the factors of ARLB were significantly positively correlated with the CLS. Among the various aspects of ARLB, "solving problems" has the best explanatory power. It shows that the higher the students' "solving problems" tendency, the higher the "CLS". The second is "try new change," which means that if the student's "taste new change" tendency is greater, the higher the "CLS." In addition, "enjoy at work" and "cautious Interaction" also have a statistical interpretation of CLS (Hair et al., 1998).

The above results indicate that students are fully confident in their creative learning. When students feel that "I can do it," the realization of innovative education is most likely. The study of CLS and motivation for AR-based learning found that the three factors of creative teaching self-efficacy are put into regression analysis. The effect of CLS on creative learning intrinsic motivation can be explained by 56.8%.

This study further tests the three factors of CLS. The results of the estimation indicate that "positive affirmation" and "tolerance of ambiguity" have statistical explanatory power, meaning that students have "positive affirmation" and " The higher the efficiency of tolerance of ambiguity, the higher the ARLM. This result supports the idea that an individual's creative self-efficacy may develop in the performance of creation and start the engine. In other words, if an individual has a higher self-efficacy, the more he can motivate himself, the more he is pleased. Therefore, students' CLS impacts AR learning motivation and is supported in this study (Reljić et al., 202; Souza et al., 2023).

These studies emphasize that motivation is an essential factor in stimulating creative behavior. The higher the motivation for students' AR-based learning, the more innovative performance they will have in education. Some study embarrassment, engaging in self-improvement, accepting challenges, maintaining an open attitude in learning and life, being able to get different experiences, and have a significant impact on student ARLE (Villagran-Vizcarra et al., 2023; Zhao et al., 2020; Ziden et al., 2022).

The structural model of ARLE factors in this study confirms that CLS is a significant change in the impact of intermediaries. The ARLB and ARLM can all be learned through creative learning. The improvement in efficiency will affect the ARLE. In addition, CLS can also influence its ARLE through the stimulation of ARLM. Therefore, the "ARLE model" proposed by the Institute can obtain practical observation data.

### 4.1. Implications for Practice

It is recommended to explore further the research that affects students' AR-based learning. It can be added to creative learning experiences, products, and other assessment tools. It is expected to have a more comprehensive understanding of students' ARLE and apply it to an AR-based creative learning curriculum. It is a crucial design approach worthy of reference to master the key points, solve problems, taste new changes, squat in them, and deliberately interact.

## ACKNOWLEDGEMENT

This paper was written while the authors were supported by a grant from the National Science Council, Republic of China. **(**MOST 112-2410-H-224-010; 109-2511-H-224-002-MY3**)**

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