How Gender Influences the Effect of Self-Efficacy on Training Success on a Mobile Curriculum

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Abstract: Self-efficacy is a key concept for understanding learner behavior and a fundamental support for improving training and learner support systems. In a context where digital technology is taking up more and more space in training systems, digital self-efficacy interferes between learners and their learning performance. Women show lower digital self-efficacy than men and may in certain digital learning contexts see themselves penalized. This study aimed at checking the effect of digital self-efficacy on a mobile curriculum with the following research question: Does digital self-efficacy play a mediating role between gender and learning performance in a digital context? After collecting and analysing data from 49 participants, we show that women's digital self-efficacy is lower than that of men, and that self-efficacy impacts learning performance. We have thus shown that self-efficacy is a key concept which plays a mediating role between gender and learning performance.

1 INTRODUCTION

In a context of enthusiasm around digital training tools, the search for effectiveness of the pedagogies proposed leads us to question the characteristics of the learners. The implications of the feeling of self-efficacy in learning in general and in the digital context are well documented. The feeling of self-efficacy has positive or negative repercussions on individuals' learning (Bandura, 1982, 1983, 1992; Rondier, 2004). Indeed, the feeling of self-efficacy can lead to learning in a virtuous circle or a vicious circle. If a learner has a strong sense of self-efficacy, he or she has a better chance of performing well, compared to an individual with a low sense of self-efficacy.

The gender of digital self-efficacy began to be studied for these reasons in the late 20th century and women then showed lower digital self-efficacy than men (Thompson and Lynch, 2003; Goswami and Dutta, 2016). The effects of gender in digital learning contexts are both understudied and also have contradictory results in research during the last decades. We were therefore interested in the feeling of self-efficacy and the mediating role that it can play between gender on the one hand and learning performance on the other hand. If an individual's success depends on their sense of self-efficacy, we wanted to first study the interaction between gender and self-efficacy on a mobile curriculum but also between self-efficacy and digital learning performance.

We will therefore present our literary review on these two subjects in the first part. We will then present the research methodology that we implemented in a mobile curriculum. We will then give the results of our research against our hypotheses before opening a discussion.

2 LITERATURE REVIEW

2.1 Self-Efficacy in Training

Bandura's various works (Bandura, 1982, 1983, 1984, 1992; Rondier, 2004) explain how self-efficacy can influence learning performance and expose its sources of influence and implications. Self-efficacy turns out to be a key concept for understanding learners' behavior and helping them in their learning.

2.1.1 Definition of the Concept of Self-Efficacy

Self-efficacy defined by Bandura (1982, 1983, 1984, 1992, 2010) “is concerned with people's beliefs in

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their ability to influence events that affect their lives. This core belief is the foundation of human motivation, performance accomplishments, and emotional well-being." (Bandura, 2010) According to the author, self-efficacy influences not only their feelings, their way of thinking and even their motivation in performing a task. This feeling impacts different processes (cognitive, motivational, affective and selection) which will themselves exert an influence on the performance of individuals. Thus, a person with high self-efficacy generally approaches difficult tasks as challenges to overcome, whereas a person with low self-efficacy may perceive the difficult task as a threat and can implement unconscious avoidance strategies. The level of self-efficacy thus influences the intensity of efforts and the implementation of strategies to avoid failure.

2.1.2 Principal Sources of Influence on Self-Efficacy

According to Bandura (1982, 1983, 1984, 1992, 2010), there are four sources of influence on self-efficacy.
An individual's past and previous experiences constitute the primary influence on self-efficacy.

Indeed, the successes previously experienced by an individual will encourage them to have a strong belief in their abilities and good personal esteem, therefore a strong feeling of self-efficacy. Conversely, failures imply a weakening of self-efficacy, especially if it is already weak.

The experiences of another individual can also influence the level of self-efficacy of a person who identifies with that referent. Witnessing a success is motivating: the witness who observes and identifies with his referent will think that he also has the means to carry out the same task. The opposite is also observable: witnessing failures negatively influences the level of self-efficacy.

An individual's beliefs are also influenced and reinforced by social persuasion, that is, by the judgment made by a third party.

A fourth source of influence comes from individuals' somatic and emotional states. These states can thus be interpreted (especially negatively in cases of stress) as proof of incompetence. Stress, fatigue and mood are moderators of self-efficacy.

2.1.3 Implications of Self-Efficacy in a Training Context

According to Bandura (1982, 1983, 1984, 1992, 2010), there are four sources of influence on self-efficacy.

Influences On Cognitive Processes
Self-efficacy interacts with cognitive processes leading to individual success. Indeed, the definition of objectives by an individual is linked to the self-assessment of his abilities. This is why the more self-efficacy an individual has, the more demanding the goals they set will be. In addition, their commitment to carrying out the tasks contributing to their success will also be stronger. Its action plan will thus make it possible to visualize scenarios contributing to success. If self-efficacy is low, the scenarios more often lead to failure and individuals are less demanding of themselves.

Influences On Motivational Processes
Self-efficacy determines the goals that people set for themselves and their level of perseverance to face difficulties. When they fail, self-doubting people reduce their efforts and give up more quickly. Conversely, individuals with a strong belief in their abilities will be more perseverant in the face of difficulties.

Influences On Affective Processes
Self-efficacy will influence individuals' stress levels and can induce depression when they face difficulties and threatening situations. Indeed, in cases of low self-efficacy, anxiety is less well controlled. Indeed, in cases of low self-efficacy, anxiety is less well controlled.

Influences On Selection Processes
Self-efficacy can influence the environment and activities individuals choose. Individuals avoid situations that would exceed their adaptation abilities and they engage in situations where difficulties are stimulating and controllable.

2.1.4 Self-Efficacy in a Digital Training Context

It is often admitted that digital tools are favorable to the training context, but on condition that individuals are trained in the use of these tools. Perceptions of technical skills thus influence self-efficacy (Coulibaly and Karsenti, 2013).

Self-efficacy in a digital learning context is made up of several dimensions: relationship to ICT and ease in using it, expectations of learning and development, search for self-improvement. For its reasons, self-efficacy varies depending on individuals in a digital self-learning context (Nagels, 2016).

Among these characteristics, gender may play a role in technology acceptance, feelings of digital self-efficacy, and performance in a digital learning context.

2.2 Gender and Self-Efficacy on a Digital Task

The effects of gender on digital learning and digital self-efficacy have been the subject of little research in the scientific literature and this research sometimes even shows contradictory results. It was noted at the beginning of the century in particular that women were more nervous when faced with a computer, that they were less efficient in handling computers and that they adopted a negative attitude towards computers (Jackson et al., 2001). But research has since been more mixed, showing other mediating variables, or even showing a limited impact of gender on digital performance and digital self-efficacy.

2.2.1 Gender, Digital Skills and Digital Self-Efficacy

Other parameters are also studied and compared to gender through research: age and nationality in particular. Sometimes studies even show that gender is not a significant variable for studying differences in learner behavior. Van Seters shows that gender does not act in comparison with the international character of training in the paths and strategies and the intrinsic motivation of students (Van Seters et al., 2012). Comber shows that students of both sexes can have equal levels of pleasure in using computers and that gender is not a significant variable unlike age (Comber et al., 1997).

Research focusing on the communication skills of men and women concludes that there is a difference in the communication of men and women in a e-learning context (Barrett and Lally, 1999) and that this difference would even advantage women who communicate more (Arbaugh, 2000; Johnson, 2011).

Other studies show that age and gender interact in both the development of self-efficacy and training success (Bausch et al., 2014).

A comparative study between Britain and China also shows that men in both countries use email and chat more than women and that men are more confident in their digital skills than women. The differences are greater in the British group than in the Chinese group (Li and Kirkup, 2007).

2.2.2 A Significant Role of Gender in the Construction of Digital Self-Efficacy

Much of the literature, however, shows that gender largely influences perceived self-efficacy for digital tasks (Ong and Lai, 2006), perceived usefulness and acceptance of a technology (Goswami and Dutta, 2016). Significant effects of gender on digital self-efficacy were observed: men have better self-efficacy, better confidence when using a computer and a positive outlook towards internet use (Durndell and Haag, 2002). Men would have a better sense of self-efficacy when facing digital tasks than women in a e-learning context (Thompson and Lynch, 2003). Men's perceived usefulness of technology, perceived ease of use and intention to use the computer are higher than women's and women are more influenced by their self-efficacy than men (Ong and Lai, 2006). There are mediating effects of gender between perceived learning support, intention to use, and learning performance (Wongwatkit et al., 2020). Finally, authors also show that if they do not observe differences in the use and acceptance of technologies, women have a more negative discourse on their digital skills than men. Self-assessment of digital skills and competencies is therefore strongly influenced by gender, independently of performance (Bruestle et al., 2013).

2.3 Overview

The scientific literature on self-efficacy and its implications on learning is well documented and shows the importance of taking it into consideration in training systems. Self-efficacy actually brings learners into virtuous circles, with students with high self-efficacy being more enthusiastic, organized in planning for their success, or sometimes into vicious circles since students with a low opinion of themselves skills can show avoidance strategies to avoid failure.

We chose to focus on the gender characteristic and observe whether or not it is determining in digital learning performance and in measuring learners' digital self-efficacy.

There are few research articles regarding the issue of gender and digital self-efficacy. Research shows sometimes contradictory results but which mainly show an effect of gender in the construction of digital self-efficacy. The research above tends to show this effect (Bruestle et al., 2013; Durndell and Haag, 2002; Ong and Lai, 2006; Thompson and Lynch, 2003).

It is for these reasons that there may be mediating role/effect of self-efficacy between gender and learning performance in a digital context. A mediating effect is defined by the presence of one or more variables which intervene to transmit the influence of a variable X on a variable Y (Baron and Kenny, 1986) as shown in Figure 1.

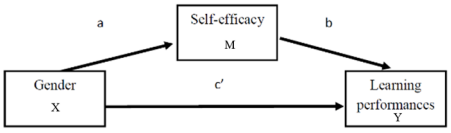


Figure 1: The mediation role of self-efficacy between Gender and Performances based on Baron and Kenny (1986).

2.4 Research Hypotheses

To demonstrate the mediating role of perceived self-efficacy between learners' gender and their learning performance in a digital learning context, we will proceed step by step by first checking two primary hypotheses.

H1: Women's self-efficacy for digital learning is lower than men's

Our first hypothesis is therefore to demonstrate that women had lower digital self-efficacy than men in a digital module for learning to pilot drones.

H2: The higher a learner's self-efficacy on a digital learning task, the higher is the learning performance.

In our second hypothesis, we want to show that self-efficacy impacts learner results. With high perceived self-efficacy, learners should therefore perform better than students with low self-efficacy (Bandura, 1982, 1983, 1984, 1992, 1992).

Then we will check this third hypotheses:

H3: Self-efficacy is a mediator between gender and digital learning performance.

3 METHODOLOGY

We used a mobile curriculum (an educational materials designed for learning on smartphones tailored to fit the capabilities and constraints of mobile technology) in order to check our hypotheses.

Our experiment aimed to observe whether gender and the feeling of digital self-efficacy had a relationship on the one hand, and whether self-efficacy and digital performance were linked on the other hand.

In order to observe these relationships, we measured the three variables: gender (informed during a questionnaire in step 1), the feeling of self-efficacy (self-assessed before the test phase in step 2) and the performance (measured by the time required to complete the journey in step 3).

3.1 Participants

In order to carry out this experiment, we recruited 49 participants who participated with their mobile.

The data was collected using a Qualtrics questionnaire complying with GDPR standards, as well as a mobile drone piloting application developed with Unity by the non-profit association AD2RV (Figure 2).

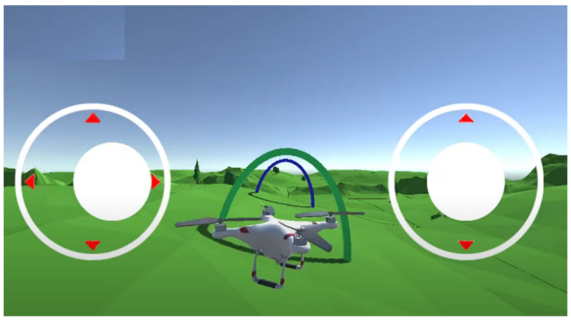


Figure 2: Illustration of the application.

The data was collected between May 2022 and July 2022

They are anonymous and were used exclusively as part of our experiment.

3.2 Experimentation Setup

The experiment has 3 steps.

Step 1: First, participants answer a questionnaire to collect socio-demographic data (age, gender). Then, they receive a code allowing them to use the drone piloting application (on Android smartphone). This code allows us to connect the data collected on Qualtrics and the control data on the Android mobile application.

Step 2: From the mobile application, after entering their code, participants watch an explanatory video of the obstacle course to be completed. After viewing the video, the participant must evaluate their degree of confidence in the task (Figure 3) which consists of completing the course in less than 45 seconds. This question allows us to assess one's feeling of self-efficacy in this task. They must rate themself from 1 to 100.

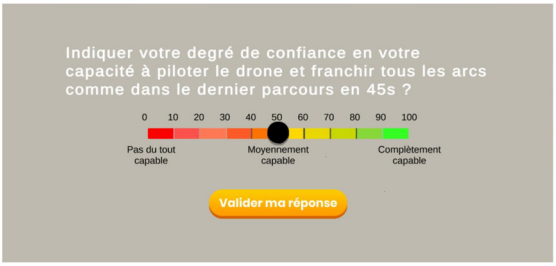


Figure 3: Self-efficacy self-assessment questionnaire

Translation: “Indicate your level of confidence in your ability to pilot the drone and cross all the arches as in the last course in 45 second” “Not at all capable” – “Moderately capable” – “Completely capable”

Step 3: During this stage, participants complete 7 guided passages including demonstrations, exercises and helps. The time of the last pass constitutes the final time which we use to evaluate performance.

4 RESULTS

4.1 Sample

49 participants were recruited using social media. From this sample, a profile can be drawn up with the following characteristics.

9 outliers were identified by the Jamovi software (time to finish the last course greater than 119.308 seconds) and excluded from the study. 19 females and 18 males were remaining.

The average age of the participants is 34 years (31.3 years for women, 35.3 years for men).

In the sample, 19 participants have never piloted a quadcopter, 11 ones have piloted a few times and 7 ones more than 10 times. The gender balance is the following: 10 women have never piloted a quadcopter while 9 men had, 8 women have piloted a few times while 3 men had, but 1 woman has piloted more than 10 times while 6 men did.

4.2 Descriptive Processing of Data

The self-efficacy about learning how to pilot a digital drone with the application is measured by a scale from 0 to 100. Table R1 and figure F1 shows that mean and median of male self-efficacy are higher than female ones which goes in the direction of H1.

Table 1: Descriptive statistics on self-efficacy and performance by gender.

	Gender	Self-efficacy	Performance (Smaller=Better)
N	Female	19	19
	Male	18	18
Mean	Female	47.5	58.1
	Male	72.6	46.6
Standard deviation	Female	24.8	18.0
	Male	23.3	17.0
Minimum	Female	10	37.7
	Male	17	35.3
Maximum	Female	100	97.0
	Male	100	94.8
Shapiro-Wilk W	Female	0.949	0.906
	Male	0.907	0.641
Shapiro-Wilk p	Female	0.382	0.062
	Male	0.076	<.001

The performance is measured though the duration to finish the last course. Thus, more this duration is small, the better is the learning of drone piloting.

The table 1 shows also the descriptive statistics about performance where we can see that male’s means are better (smaller) than female’s one.

H2 being a relationship between two quantitative values and H3 being the mediation hypothesis, we can only show this scatterplot about self-efficacy (X), performance (Y) separated by gender (Figure 4).

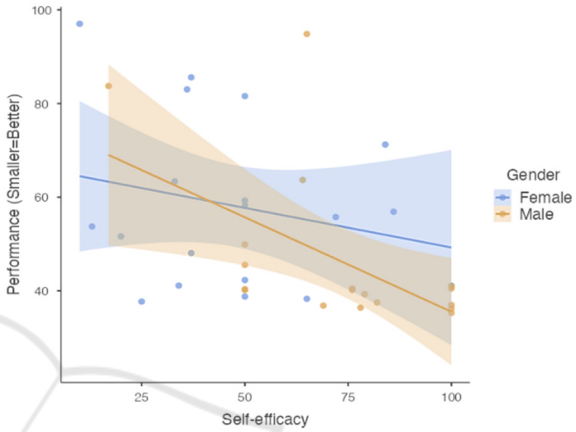


Figure 4: Self-efficacy (x-axis), performance (y-axis) separated by gender.

4.3 Inferential Statistics

To evaluate our hypothesis H1, we carry out a statistical test between the gender (two independent groups) and the self-efficacy (integer value between 0 and 100). As shows the table 1 with the Shapiro-Wilk test, the two groups are normally distributed. We proceed to a Levene’s test to check the homogeneity of variances. The result of the test (p=0.886) shows that there is homogeneity of the variances, which allows to use a Student T-Test.

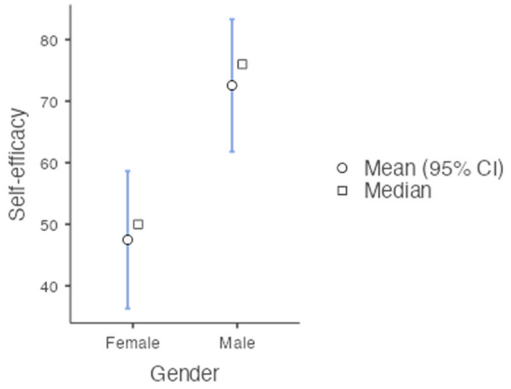


Figure 5: Self-efficacy (X), performance (Y) separated by gender.

We hypothesize that the self-efficacy will be higher in the male's group.

Figure 5 shows us the difference between the two groups.

There is a significant effect of gender over the self-efficacy ($p=0.002$) with a large effect size of 1.04.

We can conclude that H1 is verified.

To verify H2, we have to find the type of relationship exists between the digital learning performance (dependent variable) and the digital learning task self-efficacy (independent variable).

We call f this function:

"learning performance" = f("self-efficacy")

A linear regression between these variables would mean that $f(x) = a * x + b$

As the Shapiro-Wilk test between our two variables shows that there is not normal distribution ($p=0.01$), we try to transform the dependent variable to have a normal distribution.

The classical square, square root function and all affine transformations do not give any but the following function using a log10 operation:

"transformed learning performance" =
log10("learning performance" – 35.2)

We subtract 35.2 = 35.3 - 0.1 because the minimum value of the "learning performance" is 35.3, and we added 0.1 because the log10 operation cannot accept a 0-value due to its validity only on positive values.

The table 2 shows the descriptive data about the "transformed learning performance" and a Shapiro-Wilk test ($p=0.584$) shows the distribution is now normal.

Table 2: Descriptive statistics on digital learning performance and transformed one.

	Performance (Smaller=Better)	Transformed performance (Smaller=Better)
N	37	37
Moyenne	52.5	0.935
Ecart-type	18.2	0.609
Minimum	35.3	–1.02
Maximum	97.0	1.79

	Gender	Transformed performance (Smaller=Better)
N	Female	19
	Male	18
Mean	Female	1.19
	Male	0.663
Standard deviation	Female	0.434
	Male	0.658
Minimum	Female	0.399
	Male	–1.02
Maximum	Female	1.79
	Male	1.78
Shapiro-Wilk W	Female	0.928
	Male	0.941
Shapiro-Wilk p	Female	0.161
	Male	0.303

We have to keep in mind that what we call "learning performance" is representing a duration value which is smaller the better the "real" performance is.

Table 3: Linear regression between the self-efficacy and the transformed digital learning performance.

Model Fit Measures

Model	R	R^2	Adjusted R^2
1	0.542	0.294	0.274

Model Coefficients - Transformed performance (Smaller=Better)

Predictor	Estimate	SE	t	p
Intercept	1.6669	0.20975	7.95	<.001
Self-efficacy	–0.0123	0.00321	–3.82	<.001

Table 3 shows that there is a linear regression between this new transformed performance and self-efficacy with $p<0.01$ for the two coefficients and an acceptable adjusted $R^2 = 0.274$. The relationship is the following:

"transformed performance" =
1.6669 - 0.0123 * "self-efficacy"

As we are interested by performance and not transformed performance, we reversed obtain this equation:

log10("learning performance" – 35.2)
= 1.6669 - 0.0123 * "self-efficacy"

Inversing the equation results to this relationship:

"learning performance" =
35.2 + 10^(1.6669 - 0.0123 * "self-efficacy")

The shape of this relationship is presented in figure 6.

We can conclude that H2 is verified.

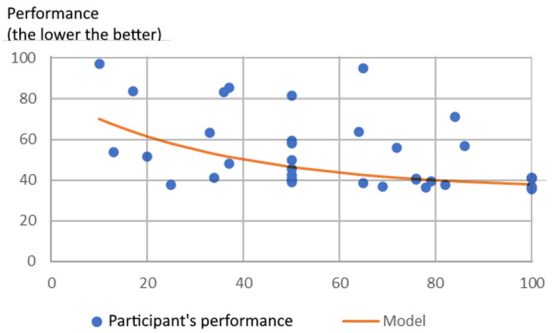
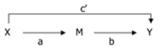


Figure 6: Relationship between self-efficacy (X), performance (Y).

H3 is a mediation hypothesis: Mediation is a hypothesized causal chain in which one variable X

affects a second variable M that, in turn, affects a third variable Y. M is the mediator as it mediates the relationship between X and Y. To verify our hypothesis, we have used a similar method as Baron and Kenny (1986) as shown in figure 7 except that our test between X and M (a) is not a linear regression because X is the gender which is a nominal variable.



	Analysis	Visual Depiction
Step 1	Conduct a simple regression analysis with X predicting Y to test for path *c* alone, $Y = B_0 + B_1X + e$	
Step 2	Conduct a simple regression analysis with X predicting M to test for path *a*, $M = B_0 + B_1X + e$.	
Step 3	Conduct a simple regression analysis with M predicting Y to test the significance of path *b* alone, $Y = B_0 + B_1M + e$.	
Step 4	Conduct a multiple regression analysis with X and M predicting Y, $Y = B_0 + B_1X + B_2M + e$	

Figure 7: Adaptation of mediation analysis steps according to Baron and Kenny (1986).

We proceed from step 1 to 4 between gender (X), self-efficacy (M) and performance (Y). As there is no normal distribution of performance for step 4 (Shapiro-Wilk test with p=0.014), we use the "transformed performance" instead (p=0.545).

Step 1: Gender to "transformed performance"

As shown in table 2, the two groups are normally distributed. There is also homogeneity of the variance (Levene's test with p=0.252), thus we can use a Student T-test. We hypothesize that females' performances are worse than male's ones.

The results are significant with p=0.003 and a large effect size of 0.957. The difference can be seen in figure 8.

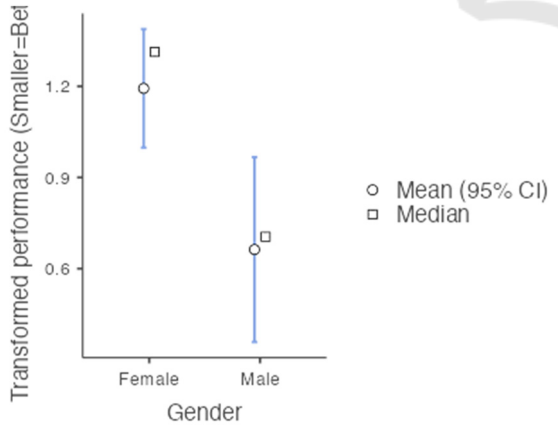


Figure 8: Comparison of performance according to gender.

Step 2: Gender to self-efficacy

It has been proven though H1.

Step 3: Self-efficacy to "transformed performance"

It has been proven though H2.

Step 4: Analysis of gender and self-efficacy (mediator) predicting "transformed performance"

According to Baron and Kenny (1986), there is a full mediation if gender does not predict performance, but self-efficacy does.

A multiple linear regression can be carried out because there is no autocorrelation (p=0.310) and normality of the distribution (Shapiro-Wilk's p=0.545).

The result of the linear regression shows that self-efficacy is predicting the "transformed performance" (p=0.010) but gender is not predicting it (p=0.141). We can conclude that H3 is verified.

As a complementary test, we also checked Step 1 with "performance", which was significant with a Mann-Whitney U test (p=0.003, Cohen's d=0.515).

5 DISCUSSION

At the end of this research work, we were able to show that women have a lower feeling of digital self-efficacy than men (H1), that the feeling of self-efficacy influences learning performance (H2) and that self-efficacy plays a mediating role between gender and performance in the sense of Baron and Kenny (1986) (H3).

A study of Bruestle (2013) has also shown that the feeling of digital self-efficacy is sometimes disconnected from the real level of learners. All of these reasons lead us to affirm the importance of increased attention to different feelings of self-efficacy in a digital teaching or training context. Education and training must help deconstruct gender stereotypes linked to digital technology and which, ultimately, disadvantage women in a digital learning context. Indeed, these stereotypes today lead women to have low self-esteem due to digital learning. This can lead them to poor strategies and avoidance strategies and close a loop of a vicious circle. The challenge of deconstructing these stereotypes is all the more important in the context of the global development of digital training. We noted three main limitations to our study.

The first limitation is linked to our sample of participants. As explained previously, the men who had piloted a drone more than 10 times were 9 compared to only 1 woman. Experts men were therefore more used to carrying out this type of task and this could have influenced our results since men and women did not have the same degree of mastery of the tools. However, we note that among the participants who have already piloted a drone "a little", 8 are women while 3 are men. The average age

of the participants is young (34 years in general, 31.3 years for women, 35.3 years for men) and can also influence the results since studies tend to show a generational effect on mastery of tools digital (Comber et al., 1997).

Another limitation is due to the actual conduct of the experiment, which is carried out independently at home by the participants. This does not allow us to guarantee a completely optimal control of the experience.

Our measure of self-efficacy is based on one question and could be more detailed, with a more developed questionnaire or even individual interviews.

A larger study could be carried out by including a better representation of different ages.

6 CONCLUSION

Our study has shown that gender influences the feeling of digital self-efficacy on the one hand and that self-efficacy influences performance in learning to pilot the drone on the other hand. We showed the mediation effect played by self-efficacy between gender on the one hand and performance in a digital learning context. Women's low sense of self-efficacy could therefore handicap them in digital learning compared to men.

We are convinced that education and training must help deconstruct gender stereotypes linked to digital technology and which, ultimately, disadvantage women in a digital learning context. Indeed, these stereotypes today lead women to have low self-esteem due to digital learning. This can lead them to poor strategies and avoidance strategies and close a loop of a vicious circle. The challenge of deconstructing these stereotypes is all the more important in the context of the global development of digital training.

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