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# An Empirical Evaluation of Tech Interventions to Improve Financial Decision-Making

## ABSTRACT

**Purpose:** This study aimed to empirically compare the degree to which two technological interventions, based on the Computer-Supported Collaborative Learning (CSCL) and the Technology Acceptance Model (TAM), were associated with a different incidence of financial biases.

**Design:** The study adopted a quasi-experimental research design. We randomly assigned the participants (N = 507) to one of two training conditions or a control group, and in turn, we assessed the incidence of financial biases after the training interventions.

**Findings:** Participants who took part in the TAM-based group reported lower financial biases than those in the CSCL-based training group and the control group.

**Research Implications:** Literature suggests that two educational approaches, i.e., the Computer-Supported Collaborative Learning and the Technology Acceptance Model, can implement individuals' financial decision-making. These educational approaches involve technology to support individuals in reducing the incidence of cognitive biases. This study contributes by advancing empirical evidence on technological supports for interventions to improve financial decision-making.

**Practical Implications:** Suboptimal decision-making may lead to adverse consequences both at the individual and social levels. Our manuscript contributes to the literature on debiasing interventions by offering initial evidence on technological-based interventions in the domain of financial decision-making. We discuss the application of this evidence in lifelong training.

**Originality/value:** This study provides evidence on how different technological interventions are associate with a lower incidence of financial biases.


*Keywords:* Financial Decision-Making; Financial Biases; Educational Tech interventions; Debiasing; Simulation Training.

## INTRODUCTION

In light of the growing spread of financialization processes, financial literacy (i.e., the level of literacy of the main components of financial knowledge and competence such as risk diversification, numeracy, compound interest and inflation, Batsaikhan & Demertzis, 2018) became a relevant concern both for individuals' private, and state economy. Countries economic growth and stability are determined by several factors, such as capital stock, human capital, financial innovation, and development, which are affected by individuals' financial literacy. However, authors reported that individuals make errors in their everyday financial tasks (Batsaikhan and Demertzis, 2018; Fornero and Monticone, 2011; Lusardi and Mitchell, 2014). Indeed, global surveys on financial literacy showed that only one adult out of three of the global population is able to deal with financial data and apply basic financial knowledge (Batsaikhan and Demertzis, 2018; Klapper, Lusardi, and Van Oudheusden, 2015). Such evidence motivated researchers and policymakers to encourage financial training interventions, supporting people to have an adequate level of financial understanding and applying their financial knowledge (Bucher-Koenen *et al.,* 2011; Mihalčová, Csikósová, and Antošová, 2014). It is in this context that authors have proposed various training initiatives. In this, technological-based interventions offer an adaptable way to foster financial knowledge. Accordingly, the present article aims to address the call for financial literacy training by providing an empirical examination of two technological-based intervention programs to limit the incidence of financial biases among participants. In particular, the present study aims at conducting an initial exploration of the possibility offered by technological interventions for the improvement of financial decision-making. In turn, this will help to answer questions on how and to what extent tech interventions can provide support for its enhancement.

Technological instruments represent a feasible and available strand for devising proper interventions (Peeters, *et al.,* 2018; Way and Wong, 2010). Current literature on financial literacy training reports how such initiatives have been developed to promote specific related aspects,

namely, financial literacy itself (Dal Santo and Martelli, 2015), financial knowledge and its application, i.e., financial competence, (Peeters, *et al.,* 2018), or financial decision-making (García and Vila, 2020). When the focus is on financial literacy, training is devised for the promotion of its core components, i.e., basic knowledge on risk diversification, numeracy, compound interest and inflation. Likewise, financial competence-based training is usually planned to promote such components via the correspondent application. Conversely, some authors suggest improving financial decision-making by helping individuals to reduce the incidence of cognitive biases, i.e., fallacious reasoning phenomena. Authors reported that individuals, no matter their level of financial education, are prone to these cognitive errors, by systematically applying irrational mental models and violating economic thought (Baker *et al.,* 2019; Park *et al.,* 2013). Such cognitive biases act as a lens on facing financial tasks suggesting that both financial knowledge and its application are not sufficient to avoid the incidence of cognitive biases (Dieckmann, 2007; Lusardi, 2012; Lusardi and Mitchell, 2014; Peters, 2006). Therefore, a prominent strand of research is represented by training interventions aimed at reducing individuals' financial biases (Baker, Kumar, Goyal, and Gaur, 2019; Duclos, 2014; Tversky and Kahneman, 1974). However, the evidence around the use of tech interventions for financial decision-making is still sparse. The literature lacks initial indications about how and to what extent specific tech interventions might be potential strategies for helping individuals to reduce biases (Peeters, *et al.,* 2018).

The study aims to provide insights on tech interventions for reducing cognitive errors in financial decision-making via a quasi-experiment research design. The contribution proposes widening the knowledge on the use of tech interventions by providing a literature review on financial literacy, financial decision-making and financial biases and an empirical exploration on the potentials of specific tech interventions. Therefore, the paper, firstly, aims at contributing to the literature on financial literacy by comprehending the role of financial biases in financial decision-making. Hence, a literature review on this object is conducted in order to identify how and to what

extent individuals with high or low financial literacy can deviate from rational choices. Secondly, the contribution extends such knowledge by presenting findings from an empirical exploration of the intervention study on how two technology-based training interventions are associated with the incidence of financial biases among participants and the corresponding promotion of financial decision-making.

## 2. LITERATURE REVIEW

### 2.1 Financial biases

Authors suggest that the role of cognitive biases is a significant concern in financial literacy, financial decision-making (Baker *et al.,* 2019; DeLong and Magin, 2009; Duclos, 2014), and financial training interventions (Dal Santo and Martelli, 2015), in which a growing number of these cognitive errors has been identified and referred to as "financial biases" (see Table 1). Their description and assessment allow researchers to understand why individuals systematically deviate from optimal decisions during financial tasks. Subsequently, these phenomena mark the basis for devising specific interventions for improving financial decision-making behaviour (Baker *et al.,* 2019; Park *et al.,* 2013).

INSERT TABLE 1 HERE

For example, in the case of consumer credit, people take care of the choices regarding the opportunity to purchase goods, so it is necessary to assess which debts to take. In that case, a common cognitive bias that can occur is the *anchoring bias*. The reference point given on two debt opportunities can lead to an irrational choice determined by the extremes of costs and benefits of the first information provided. Thus, an individual incurs this kind of bias judging the following options according to the opening one (Kahneman and Tversky, 1974). Then, individuals' risk of disadvantage interests, fixed or variable, may increase with enormous consequences for their financial situations. In other cases, some individuals would show high aversion to risk (i.e., the *aversion to ambiguity* and the *zero-risk bias*, Baron, Beattie, and Hershey, 1988; Fox and Tversky,

1995) or high preference for representations over numerical values (i.e., *information biases*, Tversky and Kahneman, 1983; *representation bias,* Kahneman and Tversky, 1972). Due to the low level of comprehension of financial information, individuals prefer to avoid ambiguities and base their decisions more on representative information rather than numerical data. These inadequate preferences can be observed, for instance, during the evaluation of the interest rate on the savings account per year considering the inflation indexes. Confounding information or avoiding pieces of information regarding the purchasing power of the currency can lead to misunderstanding prices and interests. Then, when individuals make this kind of error, they may occur in risks for their savings during personal investments (Sartori and Ceschi, 2013).

Moreover, numerical information about financial situations can be underestimated when individuals widely focus more on their interests or personal representations. They engage in cognitive biases in which the individuals' representations of the data do not concern the value itself because their preferences act as a lens on judging information. Indeed, on making decisions about general financial tasks, the *conjunction fallacy* (the inclination of representative information over numbers; Rieger, 2012) is the cognitive bias that occurs when individuals avoid the numerical data given in favour of their temporary personal preferences, mental representations (Abreu and Mendes, 2012; Kahneman and Tversky, 1972), or affections (Kahneman, Ritov, and Schkade, 1999). Likewise, the evaluation of monetary values could be made in a nominal way rather than real value (i.e., the *money illusion* occurs when even the numerical value is not considered in the view of the mental representations and the nominal value; Shafir, Diamond, and Tversky, 1997). Or again, via individual personal accounts that violate the correct reasoning (i.e., the *mental account error*, Shefrin and Thaler, 1992; Thaler, 1985; 1994). In these cases, individuals focus on partial and local proprieties in economic choices, either on investment or consumption. Different stocks for different purposes of investment or expense divide the wealth diverging to the economic reasoning where money can be used or intended for whatever purpose. A typical case is a process occurring when

families apply three different accounts during investment decisions. One account consists of one security reserve for unforeseen events while one forms the most substantial part of the wealth owned by the family, and the assets are invested in prudent financial instruments (government bonds, postal bonds, etc.) to maintain and save the family's wealth. Finally, the last one is for enrichment. After having invested in the first two accounts and still having the availability of resources, individuals can move on to the third. Here the goal is the desire for enrichment, thus raising the return on investments with a consequent increase of risk, investing in stocks, private equity, commodities, etc. Therefore, mental balances cause two finances, taken in the same time frame. However, each investment has opposite trends that families cannot compensate as belonging to two separate mental accounts (Thaler, 1985; 1994).

Although cognitive biases seem to be the expression of individual differences and seem to be difficult to eliminate (Baker *et al.,* 2019; Kahneman and Riepe, 1998), their significant impact on financial decisions still calls for intervention for reducing their incidence.

### 2.2 Tech Interventions and Financial Biases

In the growing interest considering their development, different applications, and the effectiveness provided for reducing cognitive biases (Dal Santo and Martelli, 2015; Duclos, 2014; Peeters, *et al.,* 2018), technology-based interventions can be used for devising training aimed at fostering individual abilities for financial judgments and evaluations (i.e., reducing financial biases incidence). These approaches promote the practice, focusing on users' opportunities to achieve key competences, and enhancing their performance. These interventions allow teachers and trainers to (a) manipulate information, (b) give more content in a unique and useful space, and (c) provide users with the possibility to interact with real-life simulations.

Over the years, researchers provided evidence for two technological systems. Specifically, studies have described the effectiveness of training based on e-learning systems to fostering numerical and logical abilities (Zirkle, 2004). They found positive effects on the degree of financial

tasks performance by enhancing mathematical knowledge (Amagir, *et al.,* 2018). Additionally, authors have based their interventions on the use of simulations whose usage is increasingly common in several fields (Ceschi, *et al.,* 2014; Gredler, 2004). The authors supported their effectiveness by referring to the learning by doing opportunities offered (i.e., enhancing individual financial competence through the ability to manage with economic deals; experiential learning, Harter and Harter, 2010; Jones and Chang, 2014; Mandell and Klein, 2009).

In respect of financial literacy technological training, authors from separate disciplines (Way and Wong, 2010) have mainly referred to two different educational approaches that reflect and support the use of different instruments in training programs for improving financial decision-making, i.e., *Computer-Supported Collaborative Learning* (CSCL) and *Technology Acceptance Model* (TAM). On the one hand, authors that support the Computer-Supported Collaborative Learning theory conceptualise the learning process given by social interaction thanks to the use of computer systems, which is related to the Collaborative Learning and Computer-Supported Cooperative Work (CSCW). On the other hand, the Technology Acceptance Model (TAM) supports the usage of simulations basing on the usability of technology.

In this theoretical framework, authors differ from the conventional approach of education systems in which the trainer is the primary source of knowledge and skills (Rosé *et al.,* 2008). CSCL was designed as a method with research implications on constructivism and social cognitivism (Stahl *et al.,* 2006), where the learning process is featured by the interdependence and the development of knowledge among participants, by using technology as the primary way of communication or as a shared resource. The TAM focuses on supporting the use and acceptance of technology, which is considered the point of strength in TAM approach since training is firstly intended to facilitate the users, both unskilled and experienced, during the program (King and He, 2006; Šumak, Hericˇko and Pušnik, 2011).

Coupling the knowledge on financial biases with evidence on the effectiveness of tech interventions, authors have involved technological instruments for initiatives to meet individuals' needs for financial competences and financial decision-making (Ceschi *et al.*, 2014; Dal Santo and Martelli, 2015). These attempts of intervention have considered technological progress offers, reporting reliable results in strengthening the core abilities to avoid irrational judgments and evaluations in financial decision-making (Dal Santo and Martelli, 2015; Frączek, 2016; Król and Król, 2019; Willis, 2011).

### 2.1.1 E-learning system and Real-Game Financial Simulation

According to the CSCL literature, positive outcomes have been found during the evaluation of e-learning interventions for enhancing math abilities (Juan, Huertas, Steegmann, Corcoles and Serrat, 2008; Zirkle, 2004) and the related outcomes for financial decision-making (Amagir, *et al.,* 2018; Skagerlund, *et al.,* 2018). In this strand of research, authors share one of the central principles to most learning theories by which learning is more reliable when training participants can have pleasant interactions with program contents, materials, and their peers (Mayer, 2003; Vygotsky, 1978). Indeed, within an e-learning setting, these interactions facilitated via information technology support the use of these systems for helping individuals to foster financial abilities and financial knowledge. Such authors described the effectiveness of e-learning interventions to foster financial decision making by enhancing mathematical and numerical skills (Wolla, 2017). However, in other studies, e-learning interventions have been experimented with to promote financial decision-making, teaching clear principles regarding finance and economics (Rosacker and Rosacker, 2016).

Besides, simulations, which are experimental tasks that move learners to a different world (Gredler, 2004), share the core features of TAM for the ease of use and the usefulness perceived. Giving support to the Technology Acceptance Model, the simulation usage for learning and improving knowledge is evolving more and more openly to virtual reality, in which participants take on rules and manage knowledge and abilities to solve problems (Gredler, 2004; Ceschi, *et al.,*

2014). Three features characterise simulations: (a) participants can interact with a complex real-world condition; (b) they have roles and tasks, (c) and they can experience the effects of their decisions and actions (Gredler, 2004). In the literature, authors reverberate the challenge of giving evidence to the use of simulations for financial education (Totenhagen, *et al.,* 2015; Watts and Walstad, 2006). Nevertheless, they reported their effectiveness to reduce cognitive biases when managing financial tasks. Studies have proven the theoretical point of view at the basis of simulation for training, and its efficacy for improving financial decision-making (Jones and Chang, 2014). During simulations, participants report perceiving positive influence in their knowledge thanks to the training (Totenhagen, *et al.,* 2015) while authors attested the role of exercise for enhancing financial abilities considering the applications of knowledge (Dal Santo and Martelli, 2015; Harter and Harter, 2010), with the long-term maintenance of financial skills (Mandell and Klein, 2009; Rowe *et al.,* 2011).

## 3. METHOD

Since financial biases represent an important issue both for individuals' financial literacy, and country economic stability, and given the potential of tech-training programs for supporting financial decision-making, the present paper aims to contribute to the empirical knowledge for financial education aimed at reducing financial biases. Given the evidence in the literature on the technological interventions for reducing financial biases, the present paper intends to explore how different interventions, i.e., CSCL-based and TAM-based, are associated with the incidence of financial biases among participants (Ceschi, *et al.,* 2014; Dal Santo and Martelli, 2015). Accordingly, we hypothesized that the CSCL-based and TAM-based interventions will implement students' abilities to recognize cognitive errors with a decrease of their incidence if compared to students without training. Toward our interdisciplinary literature, we propose to examine the potentials of tech interventions to individuals' incidence of financial biases. We, therefore, propose

an initial step in the domain of financial literacy via the initial exploration with a quasi-experimental design to rule a new avenue of research (Spector, 2019).

### 3.1 Procedure

At the beginning of the study, participants were assigned to one of three different groups, i.e., to either one of the two experimental groups, (i.e., a CSCL-based and TAM-based interventions) or to the control group. For the CSCL-based condition, we devised a tech intervention considering the offer of the online platform system for distance learning *Moodle* (Moodle.org). For the TAM-based condition, we devised the second intervention using a Stock Market Game simulation, *Börse* (Planspiel-Boerse, 2018). At the end of the interventions, all the participants filled in the same questionnaire, which was submitted via *LimeSurvey* (www.limesurvey.org) and included demographic variables and financial biases tasks; thus, those who were part of the control group received the same questionnaire as participants in the experimental conditions and at the same time. Participants were left anonymous, and we created an identification code for each participant before analysing the data. After data collection, financial biases were computed. Those tasks with more than one item were computed, summing the task scores to assess the direction of biases (Parker and Fischhoff, 2005).

As for the first condition, we adopted Moodle, which reflects the most advanced features required by an e-learning platform: multimedia, a high-accessible platform, and the international standards certification (SCORM-ADL compliant An Open Source Initiative, IMS LTI Certified). It allows users to communicate ideas interactively, access information, and engage in collaborative problem-solving activities. Furthermore, users can access materials to study, browse the web, search, and retrieve pieces of information from online databases. Likewise, they can download simulations, interact with case materials, and conduct virtual experiments. Course materials are present in different forms, such as text, graphics, moving images or computer simulations. Finally, as the platform is open-source, it is efficient and socially beneficial. According to our aim, we

devised the intervention toward four e-learning sessions (two hours per lesson). We explained numerical notions through the Moodle system during each session to promote financial competence. The first session concerned the theoretical framework related to mathematical and numerical concepts. Sessions number two and three aimed to develop applicative contents. The last part of the intervention presented some cases of application.

In the second condition, i.e., the simulation, the intervention procedure started with a brief introduction to financial deals and general cognitive biases. Then, participants received virtual capital to be invested in the stock market. The starting value was equal to € 20,000, and the participants had ten days to increase it. Trading activities referred to sharing prices on real stock exchanges in the major financial markets. All participants had to realise their investments and every single decision was significant for their final results, which led to understanding which judgment was better for effective strategies (i.e., for long-term or short-term profit). Therefore, the simulation allowed the participants to know how to avoid financial biases through learning by doing (Mandell and Klein, 2009).

Finally, participants in the control group had to fill in the same survey used among participants in the experimental conditions. Financial biases incidence was estimated, adopting the same classical tasks extracted from the dedicated literature.

We selected eight financial biases based on previous literature on cognitive studies (Bruine de Bruin, *et al.,* 2007; Frederick, 2005; Slugoski, *et al.,*1993; West, *et al.,* 2008), classifications of biases (Stanovich, *et al.,* 2008; DeLong and Magin, 2009) related to the financial decision-making (Baker *et al.,* 2019; Ceschi, *et al.,* 2012; Ceschi, *et al.,* 2019). We used an explorative statistical analysis to explore whether the two technology-based training interventions proposed are associated with a different incidence of financial biases among participants and the corresponding promotion of financial decision-making.

### *3.1.2 Participants*

Participants ($N$ = 507; average age 24 years, $SD$ = 7.96; range 19-56; 61.9% female) were recruited at Verona University, Department of Human Sciences. They were invited via email and, after receiving the informed consent, they were randomly assigned to either the TAM-based intervention (31.8%; $N$ = 161), the CSCL-based intervention (34.1%; $N$ = 173), and the control group (34.1%; $N$ = 173).

*3.1.3 Measures*

We devised a self-report questionnaire using the following tasks, and it took twenty minutes for completing the form. The (a) *anchoring bias* has been assessed using a task with five items (Cronbach's $\alpha$ = .708), where participants had to infer the percentage (a numeric answer) about a sentence proposed two times based on the information given with an anchor in the first presentation. An example of item is: "*Is the percentage of African countries in the United Nations greater or less than 10? Answer in the continuum from 0 to 100%"*; then the 5 items were proposed again but changing their order.

The (b) *aversion to ambiguity* is based on the notion that, generally, decision-makers dislike ambiguity (Fox and Tversky, 1995). We tested such cognitive bias with the scenario proposed by Fox and Tversky (1995), where participants have to choose one bag over another to win 100$ basing their judgment on ambiguous information.

To assess the preference of representation, we used the (c) *conjunction fallacy* and (d) *information bias*. Information bias occurs when information is managed irrationally (i.e., when more pieces of information do not lead to a better choice or individuals reach more data about the problem, Baron *et al.,* 1988). Conjunction and information biases are defined as the violation of logical norms. In these cases, people infer the answer based on representative events, which are seen as more probable than they are (Tversky and Kahneman, 1983). We tested the conjunction fallacy with the "Linda" problem, a diagnostic problem from Tversky and Kahneman (1983). Participants had to read the description of a random person, Linda. Based on this, they had to

choose which of two options better described Linda where option B gave more details than those that would have been inferred from the generic description. On the other hand, for the information bias, we presented a scenario where the participants had to judge, as hospital chiefs, which choice, out of three, was better in terms of probabilities concerning medical costs for the treatment of a dangerous disease. As noted, each of the two options has specific probabilities. However, the first option was not correct but more representative in terms of possible scenario representation.

Another bias we measured is the (e) *mental account error*. It was termed by Thaler (1985; 1994) to address a way of thinking during economic transactions. Although it is not correctly a cognitive bias, several empirical studies proposed tasks to evaluate whether (or not) individuals prefer mental calculations hindering economic reasoning (Barberis and Huang, 2001; Grinblatt and Han, 2005). We tested it introducing two times the same item, e.g., "Imagine that you are about to purchase a jacket for $125, and a calculator for $15." The second time, we changed the values of objects. Then, per each item participants were asked if they "Would make the trip to the other store?" reporting their agreement on a 6-point Likert scale from 1 = *No, I stay*, to 6 = *Yes, I go* (Cronbach's $\alpha$ = .919). The mean difference between time 1 and time 2 makes the view of the incidence of the mental account.

We proposed the "Adam and Carl" scenario to assess the (f) *money illusion* – the tendency to evaluate monetary values in a nominal way rather than the real value of money (Fehr and Tyran, 2007; Shafir, *et al.,* 1997). Presented an economic scenario, participants had to assign 1 to the person who made the best deal, and 2 to the person who made the worst. In the Adam and Carl scenario, Adam made the best long-term deal. Those who preferred Carl's statement, whose deal was monetary better but more long-term risky, incurred in the cognitive illusion.

Another example of preferring representative information over logical reasoning is (g) the *representation bias.* People prefer to consider one more representative piece of information violating the Bayesian rules of calculation (Kahneman and Tversky, 1972). Similar to the Linda

problem, participants had to choose what the job of one presented character is. The judgment happens to base on a description of the person provided with the statistics about population qualities. Individuals who choose the more detailed description (option B) that is not statistically supported, occur in the representation bias.

The eighth bias considered is the (h) *zero-risk bias,* which is defined as the preference to avoid risk and to prefer options without any sort of threat (Baron *et al.,* 1988). We presented a scenario of two cities with dangerous dumps. Considering a limited budget, participants had to choose between two options for solving the problems. The first option solves the problem of pollution, reducing cancer deaths in both the dumps. The second option is less expensive and eliminates the possibility of local death by cancer in one city.

#### *3.1.4 Experimental Procedure and Data Analytic Plan*

We used analysis of variance (ANOVA) applying the Bonferroni correction for multiple tests to explore the differences among participants regarding the incidence of cognitive biases. Specifically, we run a mixed-design ANOVA (3x8) with a between-subject factor (CSCL-based, TAM-based and Control group) and eight levels as within-subject factors for tasks (i.e., financial biases). The analysis was conducted with IBM SPSS statistics, version 21.1.

## 4. RESULTS

### 4.1 Descriptive Statistics

The descriptive statistics for the main variables include the mean and standard deviation of the eight financial biases assessed. Additionally, based on the literature, we ran a correlational analysis to assess the relations between financial biases used and to test their relations with demographic variables (i.e., age, gender, and education). In the first respect, all the variables showed strong significant relations (see Table 2), supporting their use in the financial biases' incidence. In respect of demographic variables, strong correlations were found; age was significantly related to anchoring bias ($r = .11$, $p < .05$), money illusion ($r = -.12$, $p < .01$) and zero

risk bias ($r = .17$, $p < .05$); gender was significantly related with money illusion ($r = .11$, $p < .05$) and zero risk bias ($r = .12$, $p < .05$), while education was only significantly related with representation bias ($r = -.11$, $p < .05$).

We computed the score of anchoring bias and mental account error, to assess their incidence among participants. Results showed that participants reported a medium level of such biases for each task ($M = 4.38$, $SD = 19.92$ for the anchoring, and $M = 26.35$, $SD = 34.1$ for mental account error). Scores for the other tasks range from a minimum of 0 to a maximum of 100 and meet the assumptions for normal distributions, see Table 2.

INSERT TABLE 2 HERE

**4.2 Inferential Statistics**

We explored the incidence of cognitive biases among participants after the interventions. To test follow-up differences between groups, we considered the results of the post-hoc comparison with the Bonferroni correction considering the differences per each group. Then, since the results indicated that there were significant differences among participants in different training conditions, we ran a one-way ANOVA for each measure to examine the statistical differences per task considering the descriptive statistics to verify the direction of such differences.

Mauchly's test indicated that the assumption of sphericity had been violated ($X^2(7) = .425$, $p < .001$); therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .825$). Results showed a main between subjects effect $F(2, 251) = 22.99$, $p < .001$, $\eta p^2 = .155$ and an interaction effect between groups and financial biases, $F(11.546, 1448.98) = 9.704$, $p < .001$, $\eta p^2 = .054$. The control group variance resulted significantly different from the CSCL-based group ($t = -6.763$, $p_{bonf} < .001$) and the TAM-based group ($t = -5.242$, $p_{bonf} < .007$), likewise the CSCL-based group was significantly different from the TAM-based ($t = 4.874$, $p_{bonf} < .02$).

We found that for all variables, there was a significant difference in participants of the training groups. Firstly, TAM-based participants significantly showed to be less engaged in anchoring bias [$F(2, 418) = 14.14$, $p < .001$, $\eta p^2 = .063$; $M = 1.85$, $SD = 23.84$], to less incur in conjunction fallacy [$F(2, 342) = .756$, $p < .001$, $\eta p^2 = .004$; $M = 33.14$, $SD = 29.83$] as in representation bias [$F(2, 466) = 2.757$, $p < .064$, $\eta p^2 = .012$; $M = 41.85$, $SD = 21.40$], and to avoid the application of different mental account computing the numerical information [F(2, 437) = 19.07, p < .001, ηp2 = correctly.080; $M = 30.13$, $SD = 29.85$]. Secondly, CSCL-based participants significantly showed to be less engaged in money illusion [$F(2, 355) = 25.35$, $p < .001$, $\eta p^2 = .125$; $M = 58.18$, $SD = 39.30$], and to be confident with numerical information [i.e., zero-risk bias, $F(2, 466) = 39.44$, $p < .001$, $\eta p^2 = .145$; $M = 69.95.18$, $SD = 30.41$]. For the aversion to ambiguity and the information bias, we did not find any significant differences with the control group. However, by the post-hoc comparison, each experimental group scored a similar level in the two tasks (i.e., $t = 1.190$, $p_{bonf} = 1.000$ for aversion to ambiguity, and $t = -3.487$, $p_{bonf} < 1.000$ for information bias). Indeed, by the descriptive statistics, TAM-based and CSCL-based groups scored medium-low level of aversion to ambiguous information ($M = 35.56$, $SD = 28.51$; $M = 38.62$, $SD = 30.42$), as for the information bias ($M = 61.38$, $SD = 30.42$; $M = 60.95$, $SD = 37.40$), which were different from the control group ($M = 39.05$, $SD = 30.42$).

## 5. DISCUSSION

The importance of financial literacy motivated this study, which aimed to integrate financial literacy interventions with tech education, where we have found the basis for devising our training. We have considered the importance of financial literacy, financial competence, and its related issues to the decision-making with the occurrence of financial biases. The lack of financial literacy has many implications in one's life (Lusardi, 2015) as for one's country economic stability. This work aimed to explore how participation in different interventions is associated with differences in financial biases.

In the field of lifelong training, researchers are used to adopting this paradigm of tech-based intervention for vocational training programs (Neirotti and Paolucci, 2013). This methodological approach promotes the practice, focusing on workers' opportunities to achieve key competences, enhancing their performance, and stressing the role of tech-based training. Moreover, by the side of financial education, although the extensive literature concerning financial literacy has prompted researchers to find evidence for financial education interventions, empirical examinations of technological interventions to foster financial knowledge application by helping individuals to avoid financial biases are limited (Dal Santo and Martelli, 2015; Król and Król, 2019; Willis, 2011).

We followed such indications by referring our vocational and educational training programs to two grounded tech-training theories: CSCL and TAM. Based on the CSCL theory and according to studies reporting the effect of e-learning systems, for reducing financial biases by enhancing numerical and mathematical abilities (Amagir, *et al.,* 2018; Juan, *et al.,* 2008; Zirkle, 2004). In the first case, we used the online platform *Moodle* for distance training. Secondly, we devised a tech intervention TAM-based, following studies reporting the value of simulations for financial literacy (Dal Santo and Martelli, 2015; Harter and Harter, 2010; Jones and Chang, 2014; Totenhagen, *et al.,* 2015; Watts and Walstad, 2006). By the assessment of the incidence of financial biases using self-reported measures, we aimed to explore such incidence among participants who attended the interventions and their comparison with a control group. We found a significant difference between the training groups and the control group. To further explain this significance, we investigated the direction of the improvement and assessed the differences in tasks scores. In general, the control group showed a higher incidence of financial biases over the TAM-based group and the CSCL-based group.

These results give support to the previous literature, especially for TAM-based, concerning the effectiveness of simulations as a means for supporting individuals in recognizing their judgmental errors and improving financial decision-making (see, Ceschi *et al.*, 2012). Recently,

academics and politicians have been giving large attention to debiasing training (Ceschi *et al.*, 2017). These are specific interventions aimed to help individuals avoiding cognitive biases. Although the present examination did not adopt this paradigm, the training interventions for reducing financial biases represent a contribution in this strand of research. Our study highlights that individuals are capable to understand how cognitive errors can occur and the connections between concepts, break down information and rebuild it with logical connections. Training individuals' facts about cognitive biases allowing them to understand how these might impair their tasks can be an active way of enabling students the development of financial decision-making competence.

These findings encourage authors to develop tech interventions, including a comprehensive examination of the financial literacy and competences core theories. Simulation offers the opportunity for users to apply knowledge in a concrete context and to learn by doing. We suggest that this knowledge can be transferred outside the context of gaming in dealing with similar tasks where individuals need to apply their financial knowledge. Moreover, e-learning intervention could promote financial abilities by connecting theoretical backgrounds with practical exercises. Thanks to the teaching sessions and the comprehension of financial contents via the material shared, we found significant results of a lower incidence of cognitive biases in participants' performance.

### 4. 1 Practical implications

Our findings suggest possible applied implications for lifelong training in the decision-making, vocation, and education training field. Then, our advice to improve students' financial literacy is to provide school and academic curricula with tech instruments, mainly simulations, for fostering learning-by-doing experiences aimed to prompt the abilities to solve economic problems and tasks. Moreover, each tech intervention may be combined to contribute to the theoretical and practical knowledge of the students. Financial literacy is relevant even for those who are not yet in education. Training providers could fulfil their offers with financial training using tech offers.

Especially, simulations can be flexible interventions for effortless training given to workers and supporting them to overcome their possible resistance to training activities. Additionally, the use of simulations and e-learning systems could contribute to encouraging workers' financial responsibility and literacy.

### 4. 2 Limitations and future research

The present study is not without limitations. Considering the CSCL-based intervention, we did not prompt the abilities for managing financial tasks, aiming to foster math abilities as cores for financial literacy. The results showed that participants of the CSCL group were able to reduce the incidence of cognitive biases through math knowledge and number comprehension; however, a better improvement would be seen adding more specific content on everyday financial tasks and financial biases.

Furthermore, we just made the post-intervention measurements. For a better evaluation, a *pre-* and *post-* test would cover this gap. Furthermore, we did not consider social desirability (Sartori, 2008; Burro *et al.,* 2011). Then, our measures of financial biases do not consider all the possible advantages or disadvantages of the training aimed at reducing financial biases. We encourage researchers to consider a test that could verify all these psychometrical aspects and multiple problems related to the individuals' training.

## 6. CONCLUSION

Based on the world rankings for financial literacy, the growth of finance charges in modern society has impacts on all individuals with lower levels in financial knowledge and abilities, which may affect their countries economic stability. We discussed the role of tech interventions to cope efficiently with financial biases. In the wake of this perspective, vocational and educational training for financial decision-making represents a relevant issue in the view of possible implications for workers and organisations, and modern society calls for new competences and innovation for enhancing the related key-competences (Sartori, *et al.,* 2018). Overall, we believe this study, as a

worthy contribution for further development of evidence-based studies, aimed to enhance both remote and traditional education as well as to give stronger interest in financial literacy as a critical factor in modern society and the working context.

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