The Effect of Using Analogies to Integrate System Dynamics Concepts in Accounting Education

Abstract

This paper analyses whether using analogies to integrate knowledge from other scientific areas increases the level of accounting knowledge. We defined two sets of analogies, one between the physical states of water and the economic and cash flows, and another between the concepts of stock, flow and feedback that were taken from the System Dynamics field and the financial statements. An experimental study was conducted with students from a European university, who participated in an accounting revision class. The grades of the students who attended the revision class using the analogies were higher than of those who did not attend this class. These findings reinforce the power of analogies as a useful tool and validate the benefits of integrating knowledge from other areas in accounting education.

Keywords: Accounting education; Analogies; System Dynamics; Experimental study.

1 Introduction

This study analyses the effectiveness of using analogies in teaching financial accounting, and their ability to integrate knowledge from other scientific organizational areas in the financial accounting curriculum.

Curriculum issues are the most studied topic in accounting education research (Apostolou et al., 2020). The accounting education curriculum literature has presented a persistent criticism that accounting courses dedicate too much time to the teaching of accounting standards, policies, and procedures (Lawson et al., 2014) and, in doing so, they fail to embrace the many calls to integrate knowledge from other scientific organizational areas (Black, 2012; Boyce, 2008; Flood, 2014; Hopper, 2013). Despite the efforts of some educators, a substantial change in accounting curricula has not yet taken place (CIMA, 2011; ICAEW, 2012; Lawson et al., 2014, 2015, 2017; Pathways Commission, 2012, 2015), and although literature has found that most faculty members (representing academia and research) are in favour of these recommendations, optimism regarding their implementation is limited (Soroosh & Krahel, 2018). This study is relevant to accounting educators as it demonstrates that through the use analogies, it is possible to integrate knowledge of another scientific organizational field into accounting education, and still increase accounting knowledge.

This conclusion was achieved through an experimental study, conducted in two revision classes delivered to first-year students of management and economics degrees at a European AACSB-accredited university, where basic concepts of accounting are learned in a mandatory introductory financial accounting course. Revision classes are usually administered just before an exam and are more structured around reviewing conceptual understanding and enhancing critical thinking in preparation for the exam (Mukorera and Nyatanga, 2017). The revision classes are perceived by the students as one of the most beneficial practices for their academic

performance (Mukorera and Nyatanga, 2017), and by the lecturers as an important opportunity to summarise what was learned (Volpe, 2005).

The treatment used in this study takes advantage of analogies' ability to teach complex concepts and innovative ideas, by using previously knowledge to acquire new knowledge (Alexander & Murphy, 1999; Billing, 2007; Brown, 2009; Perkins & Salomon, 1994). In the design of this revision class, two sets of analogies were applied. The first one uses the characteristics of the physical states of water (liquid, gas) to highlight the difference between economic and cash flows. The second, still using the characteristics of water, borrows the backbone structure of Systems Dynamic (SD) theory, namely its three main concepts of stocks (the quantity of an element at a given point in time), flows (input/output movements of stocks between two different points in time), and feedback (Sterman, 2004), to define and relate the Statements of Financial Position, Comprehensive Income and Cash Flows, thus allowing the integration of knowledge from another scientific organizational area into accounting education. The selection of SD as the scientific organizational area used for this integration seems appropriate given that the relationship between SD and accounting is already establish in the literature (e.g., Kameyama et al., 1989; Yamaguchi, 2003; Melse, 2011).

In the experimental study, the students were randomly assigned to two groups, a treatment group that experienced the revision class using the analogies and a control group that experienced a standard revision class. The results of this experiment show that the grades in the mid-term exam of the students who attended the revision class using the analogies are statistically higher when compared to the students who attended the standard revision class. However, given that the learning process is also influenced by individual variables that interact with instructional choices (Lee & Anderson, 2013), we also computed (for each student) a set of individual variables relevant to learning and we demonstrated that the effect of using the analogies is still valid even after controlling for those individual variables.

Contribution

Our results contribute to the literature on the role of analogies in accounting education (e.g., Hanson and Philips, 2006; Tucker, 2017), by providing empirical evidence of a successfully structured strategy for using analogies in accounting education. Appendix 1 shows the analogies in detail, so that accounting educators can use these or get inspiration on how to develop new analogies in their own classes. By showing that it is possible to successfully use analogies to integrate the basic concepts of SD when teaching introductory financial accounting, this study also motivates financial accounting educators to use analogies to develop curricula that integrate skills from other organizational science areas, and consequently address literature's main concern regarding accounting education curricular issues (e.g., Lawson et al., 2017). Our results also contribute to the emerging accounting literature that analyses the relationship between accounting and SD that apparently can bring benefits to both fields (e.g., Kameyama et al., 1989; Yamaguchi, 2003; Melse, 2011). By developing an experimental study with random assignment to the conditions, which is considered the appropriate procedure to assert causal relationships (Thau et al., 2014), this study contributes to increase accounting education's field credibility, as it answers to literature' critique regarding methodologic concerns (Apostolou et al., 2015, 2016; Rebele & St. Pierre, 2015). Finally, this study offers some novelty in terms of setting, as it relies on data from a central European university, a setting which is not common in previous research.

This paper is structured as follows. Section 2 presents the literature review. Section 3 characterizes the research design. Section 4 presents and discusses the empirical findings, and Section 5 presents the conclusions.

2. Literature Review

2.1. Accounting Education with Analogies

By using their neocortex, human beings have the unique ability to understand a structure of elements, its variations, identify recurrences, and organize all into patterns (Kurzweil, 2012). These patterns, or ideas, are used in a cumulative process in more complex and elaborate configurations to create a repertoire of extremely adaptable concepts, which seek to align with each other (Hofstadter, 2001). The ability to establish these relationships or alignments is a central element of the human cognitive process called analogy (Holyoak et al., 2001).

In this context and considering that a concept itself consists of a set of analogies, the act of thinking can be seen as a fluid movement from sets of analogies to sets of analogies, i.e., from concept to concept (Hofstadter, 2001). This cognitive process of fluid movement or alignment from a domain X (source) to a domain Y (target) is characterized by accessing, in the long-term memory, to a familiar analogy (source) with the potential to be mapped to the target, then by identifying, in the short-term memory, the systematic correspondences between domains and finally by aligning the two domains (Holyoak et al., 2001). This mechanism allows the production of inferences from the source to the target, functioning the analogy as the catalyst for the creation of a new category that incorporates both domains (Gentner & Holyoak, 1997).

Analogies are the tools that scientists, philosophers, and psychologists recognize as having the potential to acquire radically new knowledge through already obtained one (Vosniadou, 2009). Therefore, analogies have been widely used as a teaching strategy (Davis, 2013; Glynn, 2007; Harrison & Treagust, 1993; Justica et al., 2018; Rigolon & Obara, 2011). Glynn (1994) reminds that teachers and textbook authors routinely use analogies to explain complicated concepts to students, despite being often unaware - they do it automatically. Teachers regularly preface their explanations with colloquial expressions such as “It’s just like …”, “It’s the same as …”, “Think of it as …”. The advantage of teaching with analogies is that it capitalizes on students’ relevant existing knowledge (Glynn, 1994).

Using analogies as a teaching strategy has been analysed by researchers. Glynn (1994) suggests that the strategy for using analogies should be systematic, otherwise they would create confusion and misconceptions causing more harm than good. For example, students might not identify a suitable analogy, might not recognize how the taught target domain is like the source domain to which it is compared, or may fail to realize where the analogy breaks down (Haglund, 2013). Despite the empirical literature providing mixed results on whether analogies enhance learning (Crandall & Phillips, 2002; Novick, 1988), Glynn's Teaching-with-Analogies Model (Glynn, 1991, 1994; Glynn et al., 1995) has been validated in formal experiments and classroom settings in which the strategic use of analogies has been found to increase student's learning and interest (Davis, 2013; Glynn, 2007; Harrison & Treagust, 1993; Justica et al., 2018; Rigolon & Obara, 2011).

Given that analogies are useful for making abstract concepts more concrete (Burdina & Sauer, 2015), they have been widely adopted and investigated in science education, namely physics, chemistry, or biology (Guarini et al., 2009). Nevertheless, only a limited number of studies investigated the application of analogies in accounting education (e.g., Hanson and Phillips, 2006; Tucker, 2017).

Our study contributes to the accounting education literature and the education using analogies literature by analysing whether the use of analogies when teaching and integrating concepts from other scientific organizational knowledge increases the level of introductory financial accounting knowledge.

2.2. The System Dynamics Theory and its Relationship with Accounting

In the mid-20th century, authors from different areas of the natural and social sciences, felt the need to develop a thesis on the unification of science through the logic of systems (Hammond, 2003), which took the form of General System Theory by Bertalanffy (1968). In a clear

confrontation with reductionism, Bertalanffy (1968) defends the importance of the interactions between the constituent parts of a system and their connection with the context, as these allow the system to acquire new morphisms. The holistic view and concepts of this new philosophy of contemporary thought originated a systems science that is composed of different scientific theories, such as Chaos Theory, Systems Engineering, Control Theory, Systems Ecology, Systems Psychology, and System Dynamics (M'Pherson, 1974).

Currently, one of the most prominent theories in systems related to the areas of organizational knowledge is SD (Davahli et al., 2020; Rebs et al., 2019; Zanker and Bures, 2022). This theory is distinguished by considering that the components of a system are divided into stocks and flows that, in their permanent interactions over time, are affected by an internal feedback effect (Sterman, 2004). Stocks are the quantity of an element, a component, or a variable at a given point in time (Ford, 2019), and they characterize the state of the system at that specific date. Their existence comes from the lack of synchronization between the incoming and outgoing flows, the input/output movement of quantities between the stocks in a determined period (Ford, 2019).

Accounting, as the language of business, intends to represent a system (an organization) where these concepts of stocks, flows, and interactions that characterize the SD are also found. The Statement of Financial Position represents a company's stocks at a given time, whose values vary according to the inflows and outflows that occur in each period. These inflows and outflows may have an economic or monetary nature, the first being presented in the Statement of Comprehensive Income and the second presented in the Statement of Cash Flows.

The conceptual proximity between SD and accounting has already been identified in the SD literature, as Sterman (2004) attests: "*In accounting, balance sheet items are stocks, such as cash, the book value of inventory, long-term debt, and shareholder equity (all measured in, e.g., dollars). Items appearing on the income statement or flow of funds report are flows which alter*

the corresponding stocks on the balance sheet, such as net receipts, the cost of goods sold, long-term borrowing, and the change in retained earnings. These flows are measured in $/year" (p. 197).

The accounting literature has already recognized the connection between accounting and SD as well. Kameyama et al. (1989) introduced Accounting Dynamics as a methodology for modelling and simulation of accounting using SD, and Pierson (2020) documented a model that replicates the accounting reporting process within an SD framework, allowing future modelers to incorporate these structures into projects that would benefit from more robust accounting structures.

There is already also an emerging accounting literature that analyses the application of the SD concepts in the accounting field. Yamaguchi (2003) stresses the limitations of the current accounting and presents a consolidated set of accounting SD principles and Melse (2011) redefines the accounting equation as a dynamic stock and flow model expressing the two dimensions of the double-entry accounting system.

In our case, the study analyses if it is possible to use analogies to integrate concepts of SD and increase the level of accounting knowledge. The integration of the main concepts of SD in curricula and teaching structures is already perceived as useful (Alessi, 2000; Chow & Cheung, 1992; Forrester, 2016; Gould-Kreutzer, 1993). However, by extending it to introductory financial accounting, thus answering the main concern of accounting education curriculum literature, this study contributes to expand the field of accounting/SD relationship into the education, which is, to our best knowledge, not yet accomplished.

Accordingly, the following hypothesis was tested: Using analogies to integrate knowledge from other scientific organizational fields (namely System Dynamics) into accounting education is associated to a higher level of introductory financial accounting knowledge.

3. Research Design

To test the hypothesis, an experimental study was developed.

Experimental studies have gained increasing acceptance as a suitable methodology for research in accounting (Hurley et al., 2018; Jiang et al., 2018; Norman et al., 2020; Reimsbach et al., 2018; Young, 2021) and mainly in accounting education (Arain et al., 2018; Gilar-Corbi et al., 2018; Grivokostopoulou et al., 2019; Otte et al., 2019; Wu et al., 2018). In an experimental study, the researcher controls the application of a treatment, manipulating one or more independent variables, to observe the effects on one or more dependent variables (Fraenkel et al., 2015).

3.1. Participants

The participants in this experimental study are students who attended the first year of the management and economics degrees at a European AACSB-accredited university in the academic year 2019/2020. These two degrees (Management and Economics) have a mandatory introductory financial accounting course which is taught in the first semester of the first year, with teaching activities between September and December, the period in which the experimental study was conducted.

This course has three learning objectives, namely, to understand the purpose of financial accounting, understand the structure and content of financial statements and analyse and describe the effect of business decisions and transactions on the financial statements. The evaluation of the students in this course is performed through a mid-term exam carried out in the middle of the semester that represents 25% of the final grade, and both group work and an individual final exam that represent 15% and 60% of the final grade, respectively.

3.2. Setting and Educational Background

For conducting the experimental study, all students who entered for the first time in the management and economics degrees of this European university and, consequently, attended for the first time the introductory financial accounting course in the academic year 2019/2020 were selected. There were 303 students (134 men and 169 women), with a minimum GPA of 16.75 out of 20.

To ensure that all the students participate in the experimental study under the same conditions, one group of students with classes in the afternoon (most students have classes in the morning) and two groups of students that are taught in a different language were eliminated, which reduced the number of participants to 247 students.

In the European country where the experimental study was carried out, secondary education does not include any accounting course. Additionally, the average age of the students is 18 years old, only three students (1.76%) had required the student/work status, which indicates that almost all students weren't having any professional experience. Therefore, we may be confident that almost all the selected students are exposed for the first time to the introductory financial accounting curriculum, mitigating the effects of potential prior knowledge. On the other hand, the very high value of the minimum GPA of the selected students (16.75 out of 20) which is a feature of this University, also provided some confidence on a high level of uniformity between the students regarding academic knowledge.

3.3. Procedures

A presentation about the experimental study was held in class explaining its purpose. The students were invited to attend one of two revision classes planned. The revision classes were conducted on October 22, 2019, at 1:30 pm, under similar conditions and circumstances as the other theoretical classes of the semester, namely, they were held during the day, using the same computer tools (Microsoft PowerPoint®) and in rooms regularly used by the students in the

introductory financial accounting course classes. Additionally, the revision classes were given only four days before the mid-term exam, when the students were preparing for it, in order not to create any maturation effect (Campbell & Stanley, 1963).

The students were randomly assigned to two groups (Group 1 and Group 2), one for each revision class. This random assignment to the experimental conditions, as suggested by Fisher (1935), makes it possible to increase the likelihood that the effect of the error caused by exogenous factors is equally distributed across each of the two conditions and thus ensure that the average influence of this error is the same in both groups, which largely reduces the differences between the conditions (Fraenkel et al., 2015; Shadish et al., 2002; Stangor, 2010). A strong internal validity is essential, as this is the only way to demonstrate that the use of these analogies was associated with a higher level of introductory financial accounting knowledge.

After excluding: i) students who did not attend the classes, because they chose not to participate; ii) students that attended a different class than the one they were assigned, and iii) students who did not attend the mid-term exam, the final sample is composed of 170 participants (74 men and 96 women). All the selected students signed a list guaranteeing evidence of their acceptance and participation in the experimental study.

3.4. Manipulation (Independent Variable)

From the 170 participants of the experimental study, 84 belong to Group 1 (treatment group) and 86 belong to Group 2 (control group). The students of Group 1 attended a specific revision class using analogies to integrate the concepts of SD into accounting education. This revision class was based on a presentation supported by 24 slides, which was built with reference to two models for introducing the use of analogies, one described in Vosniadou (2009): i) access and identification of the source system, with some similarity to the target system; ii) mapping of the relationship structure from source to target; and iii) assessment of the applicability of this

relationship; and another in Glynn, (1991) (Glynn's Teaching-with-Analogies Model): i) introduction of the target domain; ii) review of the characteristics of the source domain; iii) identification of similar characteristics between domains; iv) mapping of similar characteristics explicitly; vi) indication of where the analogy ceases to apply, and vii) concluding.

The analogies focus on two main areas, the difference between financial and the economic perspectives of accounting information (the accrual principle), and the different financial statement's purpose and relationship. The details of this revision class are presented in Appendix 1.

The students of Group 2 (control group) attended a standard revision class that consisted of a selection of the 18 most important slides taken from the theoretical classes that were taught during the semester, highlighting the most important concepts covered by the mid-term exam. These concepts were revisited, and all doubts and misinterpretations were clarified. Therefore, both groups had the same number of lessons and the difference between them is the content of the revision classes.

Consequently, one independent (binary) variable is used, which measures whether analogies to integrate the SD concepts (SD_ANALOGY) were applied in teaching introductory financial accounting. This variable was manipulated by the attendance or not to the revision class who uses the analogies.

To demonstrate the validity of the independent variable, a manipulation check was also performed. The students that were part of the experimental study and attended the revisions classes were given a questionnaire, with one question to be answered on a 7-point Likert scale ("Did the professor make comparisons with topics other than accounting, that is, did he use analogies?"). The results of this questionnaire were analysed through a t-test to verify if the students who participated in the revision class using the analogies to integrate the SD concepts

(in the standard revision class) had, in fact, the perception that these educational tools were (were not) used.

3.5. Dependent Variable

The dependent variable used in this study is a variable that measures the level of introductory financial accounting knowledge of students who participated in the experimental study (LEARNING). The values assumed by this variable are the grades obtained by the study participants in the mid-term exam of the introductory financial accounting course conducted on October 26, 2019 (four days after the application of the treatment, i.e., the specific revision classes).

This mid-term exam aims to evaluate the students' knowledge regarding the financial statements, namely their objective, structure, content, and the effects of certain events and transactions and has a weighting of 25% in the student's final grade. This exam was conducted following what has been done every year in the assessment of the knowledge of students in this course.

Considering the validity of the construct (Bagozzi et al., 1991; Cook & Campbell, 1979), it is possible to question whether higher grades necessarily imply a higher level of knowledge. Regarding the use of exam scores to represent the students' knowledge, it is certain that evaluating the learning results is more an art than a science (Lucas & Meyer, 2003). However, as the learning outcome cannot be directly observable, exam scores are used in the accounting education literature for this purpose (Baxter & Thibodeau, 2011; Phillips & Heiser, 2011; Premuroso et al., 2011; Sargent et al., 2011).

The mid-term exam includes 20 questions, 17 of which are multiple-choice with four answer options each. The last three questions have a single answer (numerical value) to be presented by the students. Three versions of the exam were produced, with the multiple-choice questions

being the same, although presented in a different order, and the single-answer questions being identical, but using different numerical amounts in each of the versions. These procedures allowed to mitigate the risk of less ethical behaviour by the students, which could influence the values of the dependent variable.

Each of the multiple-choice questions takes the value 1 if the answer is correct, 0 if no answer is presented, and -0.25 values if the answer is incorrect, discouraging students to answer randomly. Although students may have a negative rating in some questions (multiple choice), the final rating obtained in the test is always between 0 and 20 points. The exams were graded by professors who do not know the assignment of each participant to each of the conditions of the experimental study. Therefore, any noise caused by the potential subjectivity in the evaluation was reduced.

Despite the mid-term exam having 20 questions, only 15 questions (12 multiple-choice[1] and 3 single numerical answer[2]) were used to measure the dependent variable (LEARNING), given that 5 questions are not within the scope of the experimental study. Two questions were disregarded as they specifically dealt with the accounting standards that should or could be applied when preparing the financial statements, one question was removed for being related

[1] These multiple-choice questions include, for example, the following:
Which of the following statements is correct?
a) The Balance sheet aims to measure the entity's financial position, as it presents the changes in the entity's assets, liabilities, and equity during a reporting period.
b) The Balance sheet aims to measure the entity's financial position, as it presents the accumulated value of the entity's assets, liabilities, and equity at the end of the reporting period.
c) The Income Statement aims to measure the entity's return, as it presents all the changes that occurred in the entity's assets and liabilities during a reporting period.
d) The Income Statement aims to measure the entity's financial position, as it presents the accumulated value of the entity's income and expenses at the end of the reporting period.

[2] These single numerical answers include, for example, the following:
What is the cumulative effect of the following 6 transactions carried out in Year N on the amount of cash flows from operating activities in Year N?
- Purchase of a warehouse to store raw materials for 600,000 euros, with payment in N+1.
- Sale of goods, in cash, for 80,000 euros, the cost of which was 50,000 euros.
- Obtaining a bank loan in the amount of 400,000 euros, to be repaid in 4 semiannual installments of the same amount, starting in January of N+1.
- Electricity consumption, in the amount of 10,000 euros, payable in N+1.
- Reimbursement of a debt to suppliers, in the amount of 30,000 euros.
- Purchase of goods, on credit, for 70,000 euros.

to the concept of inventories, and the other two questions were removed for being related to the rules for handling the double-entry method. Consequently, the value of the dependent variable (LEARNING) can vary between 0 and 15 points (15 questions, minimum 0, and maximum 15 points). However, we performed an additional analysis with all 20 questions, and we found similar results.

The research design also considered the reliability of the results, namely the degree of consistency of the selected measure (Whitley Jr. & Kite, 2012), in this case, the student's grades. We have tried to ensure, as far as possible, the absence of random measurement error (Stangor, 2010). To demonstrate the reliability of the exam and, consequently, of the measurement achieved, we followed the Classical Test Theory (Feldt & Brennan, 1989; Kline, 1986; Lord et al., 1968; Spearman, 1904). The Cronbach's alpha coefficient (α) was chosen as the reliability instrument (Cronbach, 1951), given that it is commonly used to ensure internal consistency (Vaske et al., 2017), and is one of the most important statistical measures used in scientific research, including education-related research (Taber, 2018).

3.6. Students' Individual Characteristics Relevant to Learning

Considering that there is extensive literature demonstrating that the degree of effectiveness of educational strategies reflects not only the professors' pedagogical choices but also the individual characteristics of the students (e.g., Lee & Anderson, 2013), we analyse the relationship between the use of the analogies to integrate the SD concepts and the level of knowledge of introductory financial accounting controlling for possible effects of individual variables that the literature indicates as relevant for learning.

Thus, a questionnaire was designed with 45 questions answered on a 7-point Likert scale (Likert, 1932), encompassing two metrics related to self-regulation in the learning process (General Learning Strategies and Clarification Strategies for Learning), four metrics related to

individual motivations (Self-efficacy, Intrinsic Value, Performance Objective Orientation, and Learning Objective Orientation) and one metric related to personality orientations (Anxiety to take an exam). This questionnaire was distributed and completed by the randomly selected students that accepted to participate in the experimental study on October 22, 2019.

The General Learning Strategies and the Clarification Strategies for Learning were evaluated using instruments validated by Dunn et al. (2012) based on a review of the Motivated Strategies for Learning Questionnaire - MSLQ (Pintrich et al., 1993), the common tool used to investigate the self-regulatory strategies in learning processes. The General Learning Strategies (LEARN_S) scale integrates five items that involve questions related to general self-regulation strategies (e.g., “When subject matters are difficult to understand, I change the way I am studying.”). A second scale is intended to measure Clarification Strategies for Learning (CLARIF_S) and is composed of three items that refer to the ability to identify and clarify confusion and misunderstandings during the learning process (e.g., “When I get confused about something that I'm studying for this subject, I go back and try to understand.”).

Regarding individual motivations, Self-efficacy (SELF_EF) was assessed using a scale proposed by Eccles (1983) and later resumed by Pintrich and de Groot (1990), which includes nine items related to perceived competence and confidence in the performance in the classroom (e.g., " I'm sure I can understand the ideas taught in this course”). The intrinsic value (INTRINSIC_V), i.e., the degree of the student's intrinsic interest in academic work, as well as the importance attributed to it, was assessed using a scale consisting of eight items (Pintrich & de Groot, 1990) relating to the student's interest in the course (e.g., “I like what I'm learning in this subject”). The Performance Objectives Orientation (PERF_O) and the Learning Objectives Orientation (LEARN_O) were assessed using two scales proposed by Button et al. (1996). The Performance Objectives Orientation (PERF_O) is the degree of concern about performance and the desire to obtain favourable judgments from others, and comprises eight items (e.g., “Other

people's opinions about my ability to do certain things are important to me."). The Learning Objectives Orientation (LEARN_O) includes eight items as well, covering the degree to which the individual wants to undertake challenging work and learn new skills (e.g., "Having the opportunity to do challenging work is important to me"). Finally, related to personality orientations, and based on the work of Pintrich and Groot (1990) as well, a four-item Anxiety (ANXIETY) to sit at an exam scale was used (e.g., "I get so nervous/nervous during tests that I can't remember what I learned").

Based on the questionnaire, the values of the individual variables relevant for learning (LEARN_S; CLARIF_S; SELF_EF; INTRINSIC_V; PERF_O; LEARN_O; ANXIETY) were computed. The value of each variable represents the average of the values of the answers obtained in each set of questions.

3.7. Data Analysis

We started by computing and comparing the mean of the dependent variable (LEARNING) in each of the two groups of students (2 experimental conditions), followed by an equality of means parametric t-test that was performed to find whether the difference between the two groups is statistically significant.

Secondly, to find whether the results are robust after controlling for possible effects of individual variables that the literature indicates as relevant for learning, we estimate a regression model according to Equation (1).

$$LEARNING_i = \alpha_0 + \beta_1 SD\_ANALOGY_i + \gamma \sum Controls_i + \varepsilon \quad (1)$$

where, for each student *i*, LEARNING is the grade obtained in 15 of the 20 questions (those related to the financial statements) of the mid-term exam of the introductory financial accounting course, and SD_ANALOGY is a dummy variable that assumes 1 if the student attended the

revision class using analogies to integrate SD concepts and 0 otherwise. The control variables are the seven individual variables relevant for learning, namely, LEARN_S (general learning strategies), CLARIF_S (clarification strategies for learning), SELF_EF (self-efficacy), INTRINSIC_V (intrinsic value of the course), PERF_O (performance objective orientation), LEARN_O (learning objectives orientation), and ANXIETY (students' anxiety).

The intercept (α_0) represents the expected value of the dependent variable (LEARNING) assuming the value 0 for all the independent variables. The coefficient of the main independent variable (SD_ANALOGY) (β_1) represents how much the dependent variable (LEARNING) increases on average for the students that attended the revision class using analogies to integrate SD concepts, when compared to those attending the standard revision class, holding all the other independent (control) variables constant. The coefficients of the control variables (γ) represent the marginal effect of each control variable on the conditional mean of the dependent variable, holding the remaining independent variables constant. The error (ε) represent the unexplained part of the dependent variable.

4. **Empirical Findings**

4.1. Descriptive Statistics

Table 1 presents the descriptive statistics of the dependent variable for the entire sample and for each of the two experimental conditions (groups). The dependent variable used in this study (LEARNING) is a variable that measures the level of introductory financial accounting knowledge of students who participated in the experimental study. The values assumed by this variable are the grades obtained by the participants in the mid-term exam of the introductory financial accounting course in the 15 questions that fall within the scope of the experimental study (financial statements). Overall, the mean value of the variable LEARNING is 8.919,

which means that 59.46% of the questions were answered correctly. The minimum (maximum) value of the LEARNING is 0 (15), which means that there is at least one student who did not answer any question correctly (answered all the questions correctly). The reliability of the measuring instrument (the knowledge assessment test) was validated by a Cronbach's alpha of 0.773. Since the Alpha test is greater than 0.7, the internal consistency of the data and consequently the reliability of the results can be demonstrated (Taber, 2018).

TABLE 1

In Group 1, consisting of students who attended the revision class using analogies to integrate the concepts of SD, the mean value of the variable LEARNING is 9.613. In Group 2, consisting of students that attended the standard revision class, the mean value of the variable LEARNING is 8.241. The result of the equality of means parametric t-test shows that this difference is statistically significant. Therefore, these descriptive statistics provide preliminary evidence that the introduction of a revision class using analogies to integrate the concepts of SD positively affects the students' accounting knowledge related to the scope of the experimental study (introductory financial accounting - financial statements).

Table 2 presents the descriptive statistics of each of the individual variables relevant for learning (LEARN_S; CLARIF_S; SELF_EF; INTRINSIC_V; PERF_O; LEARN_O; ANXIETY) for the entire sample and for each of the two experimental conditions (groups). The results of the equality of means parametric t-tests show that the differences between Group 1 and Group 2 are not statistically significant (except for the variable CLARIF_S, but with a *p*-value of 0.080). Table 2 also present the result of the manipulation check that was performed to verify if the students who participated in the revision class using the analogies to integrate the SD concepts (in the standard revision class) had, in fact, the perception that these

educational tools were (were not) used. The difference between the mean of the variable MAN_CHECK_ANALOGY between the two groups is statistically significant.

To demonstrate the validity of the independent variable, a manipulation check was also performed. The students that were part of the experimental study and attended the revisions classes were given a questionnaire, with one question to be answered on a 7-point Likert scale ("Did the professor make comparisons with topics other than accounting, that is, did he use analogies?"). The results of this questionnaire were analysed through a t-test to verify if the students who participated in the revision class using the analogies to integrate the SD concepts (in the standard revision class) had, in fact, the perception that these educational tools were (were not) used.

TABLE 2

4.2. Regressions Results

Table 3 presents the results of the estimations of Equation (1), including only the main independent variable (C1), only the control variables (C2), and all the variables together (C3). These results confirm that the use analogies to integrate the concepts of SD allows increasing the level of knowledge of introductory financial accounting, given that the coefficient of the variable SD_ANALOGY is positive and statistically significant, regardless of whether the individual variables relevant for learning are included (C3) or not (C1) as control variables.

TABLE 3

The results presented in column C1 show that the expected value of the grade obtained in the mid-term exam of the introductory financial accounting course (LEARNING) by the students that attended the standard revision class (SD_ANALOGY = 0) is 8.241 out of 15. For the students that attended the revision class using analogies to integrate the concepts of SD (SD_ANALOGY = 1), the expected value of the grade is significantly higher (9.613 = 8.241 + 1.372). The results presented in column C3 are substantially identical, but also consider the effect of the control variables.

The results regarding the individual variables relevant for learning (control variables) show that the self-efficacy (SELF_EF) and the anxiety to sit at an exam (ANXIETY) are significantly associated with the level of knowledge of introductory financial accounting, but possible differences in the level of self-efficacy and the anxiety of the students did not influence the main conclusion about the influence of using analogies to integrate the concepts of SD in accounting classes.

5. Conclusion

The empirical findings show that the introduction of a revision class using analogies to integrate the concepts of SD (instead of a standard revision class) had a statistically positive effect on the student's grades in a mid-term exam, even when controlling for the individual characteristics of students relevant to the learning process. These results support our hypothesis. Therefore, it seems that it is possible to successfully integrate skills from other areas of scientific knowledge into accounting education, which opens the door to multidisciplinary, and addresses the main problem that is raised in the literature regarding curricular issues. The assumption that the accounting student needs to know not only the accounting standards and how to record accounting transactions, but also other languages of the organization to dialogue with all its colleagues is a powerful idea that should be explored.

This study also reinforces the evidence about the positive effect of analogies in education (Davis, 2013; Gick & Holyoak, 1980; Glynn, 2007; Justica et al., 2018; Marchant, 1989; Mayer & Wittrock, 1996; Rigolon & Obara, 2011) and increases the so far limited evidence about the positive effect of analogies in accounting education, namely introductory financial accounting (e.g., Hanson and Phillips, 2006; Tucker, 2017). The analogies can be used not only to integrate skills from other areas of knowledge, as was done here, but also to teach other areas of financial accounting not yet explored, given that accounting includes a significant set of abstract concepts that creates anxiety in its students (Malgwi, 2004) and is perceived as difficult.

It seems that we were able to appropriately define the source and target domains and to access, in the students' long-term memory, a familiar analogy with the potential to be mapped to the target, thus allowing to be recognized in the short-term memory the systematic correspondences and, in this way, aligned the two domains (Holyoak et al., 2001). The water and its characteristics are easily recognized by everyone and have a latent ability to be mapped in many ways, thus becoming a reliable source topic. However, care was taken to ensure that water did not share only superficial aspects with money (target topic), but the mapping was conducted through its structural characteristics (Gentner, 2009; Ross, 1984). The analogies that were used made it possible to infer in money, characteristics that were until now only seen in the water, thus creating new knowledge (Gentner & Holyoak, 1997).

From the point of view of the specific link between accounting and SD, this study contributes to the accounting literature that explores the relations between accounting and SD (e.g., Kameyama et al., 1989; Yamaguchi, 2003; Melse, 2011), creating a new educational connection between the two. The concepts of SD proved also to be a reliable source topic for the analogies. The SD analyses the reality through a systematic perspective, allowing to understand complex structures and concepts in a logic of interconnection of elements, each coherently organized to achieve a goal (Bertalanffy, 1968; Meadows, 2008). In the specific case of introductory

financial accounting, the SD helps to understand the nature and the interconnection of the elements of the financial statements. In fact, once established through analogies, the links between the definition of stocks and the items in the Statement of Financial Position, and between the definition of flows and income and expenses (and receipts and payments) are very intuitive. The internal feedback between stocks and flows or, in the case of accounting, between the Statement of Financial Position and the Statements of Comprehensive Income (and Statement of Cash Flows) is also noticeably clear. These similarities deserve to be further explored.

However, the results of this study must be analysed considering some limitations. The empirical study that was conducted relies on only one experiment, with one revision class (with or without the analogies) and with the comparison of the students' grades in a mid-term exam. The grade obtained in this exam represents 25% of the final grade of the students, which makes it relevant for them and increases confidence in the results. Even so, the internal validity of the results may be additionally increased even further with the replication of the experiment with similar students and with other ways of students' evaluation, namely a final exam.

Also, this study was conducted in only one country, at a specific university, in a specific year, and only with introductory financial accounting students of similar ages. Thus, the ability to generalize the results will be limited until it is possible to replicate the study in other scenarios. Consequently, the external validity of the results may be analysed through additional studies on the effect of using analogies to integrate the concepts of SD in accounting education in other places, other countries, and/or with students with more advanced accounting knowledge or students with professional experience.

Finally, although we find a positive effect of the use of analogies to integrate the concepts of SD in accounting education, it is not possible to guarantee the success of the analogies in the integration of other areas, nor the integration of concepts of SD with other educational tools.

The SD and accounting share a set of basic concepts that allow the creation of valid analogies, but this is certainly not evidence for what could happen with other areas of scientific knowledge. Consequently, further studies should be developed using the same educational tool (analogies) to assess whether it is possible, and advantageous, to integrate other areas of scientific knowledge in accounting education.

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Appendix 1 – Description of the revision class using analogies to integrate concepts of SD into accounting education

The revision class using analogies to integrate the main concepts of SD starts with the teacher stimulating the access in long-term memory to the water element (source topic) and its well-known attributes, immediately creating a mapping and the first identification with money (first target topic). The water element is frequently used within SD, even the convention for modelling stock and flow diagrams was inspired by a hydraulic metaphor, with water entering and leaving reservoirs (Forrester, 1961). It is important to point out that it is unusual to put water and money side by side, but the teacher is counting on that strangeness to awaken students' interest in the rest of this session. Nevertheless, this unease is controlled by directing the student's attention to facial and superficial similarities of both domains (e.g., "water is important for life" and "money is important to everyday life"). Consequently, students are encouraged to analyse other potential aspects that can join these two concepts.

The important part of the mapping process begins by introducing one additional characteristic of the source topic (water), its ability to have several states (e.g., liquid, and gaseous states). Despite no new knowledge is being introduced at this point, as all students know about this characteristic of water already, a primal and unexpected breakthrough is made by asserting that like water, money has more than one state. Surely, students could acknowledge the superficial similarities between water and money mentioned, but money having more than one state, provokes a cognitive tension that requires answers. By this apparent unconventional idea that awakes their curiosity, the first new knowledge is in fact introduced when comparing the liquid state of water with the "liquid" state of money (financial perspective). The framework of this comparison is the focus on purpose and time variables, which are the cognitive link between the two domains. It is explained that the purpose of water (to eliminate thirst) is only possible by drinking water, right now, in its liquid state, as the ability to exchange money for

any desired goods or services is only possible if one has, right now, liquidity (cash or assets easily convertible to cash), i.e., money in its “liquid” state. Additionally, supported by the contrast with this first idea, the analogy between the gaseous state of water and the "gaseous" state of money (economic perspective) is also presented. In both, is either impossible to drink water (from clouds) or to purchase any goods or services with “gaseous” money - represented in the presentation by a production unit (tangible fixed asset) - as in this state is necessary to wait (time delay) for it to rain or to realize the economic benefits, through the production of goods, their subsequent sale and receipt from customers, respectively (time-variable > 0). Cognitively, through the analogy between the two water states and their highlighted features and the two “states of money”, the teacher introduces the financial and economic perspectives of accounting information, their characteristics, and their differences, and implicitly, the accrual principle, which tends to be an arid concept but here finds a nest in the known concept of water, as stated in Figure 1.

FIGURE 1

Then the presentation enters a new phase of the mapping and aligning process. As to manage any element implies measuring it, knowing its variations over each period (derivative) and the total quantity at any point in time (integral) is necessary to understand either water or money. Thus, the concepts of flows and stocks, the theoretical foundation of SD (Sterman, 2004), are brought into the revision class. More precisely, the concept of flow – a quantity measured over a period (a rate that relates both quantity and time) – is explained, and the analogies between the measurement of water vapor in and out of clouds, or liquid water in and out of a container and, respectively, gaseous flow (economic) – measured in the Income Statement - and liquid flow (financial) – measured in the Statement of Cash Flows - are developed. It is also explained

that the inflows and the outflows may not occur simultaneously, which allows the system to accumulate quantity, measured at any point in time, thus introducing the SD concept of stock, and analogically the concept of accounting item presented in the Statement of Financial Position. The different financial statements are then linked, as there are the flows and stock concepts, using the main idea of the fundamental theorem of calculus (integral and the derivative as inverse functions), as stated in Figure 2. Cognitively, the analogy between water and money, made this time through two main SD concepts, allows the introduction of the different financial statement's purpose and relationship in the measurement and reporting of the economic and financial perspectives of business information.

FIGURE 2

The final important part of the mapping process begins by introducing one additional characteristic of the source topic (water), the idea of the perpetual cycle between the different states of water over time (water cycle). As such, students' minds are led to another key idea of SD, the dynamic effect caused by the time variable (MIT System Dynamics in Education Project, 2015). The third fundamental concept of SD, the feedback loop is introduced thus interconnecting over time the concepts of the various flows and stocks (Forrester, 1961). The students are asked to revisit the water cycle, concluding that the total of water in the liquid state influences the evaporation flow and thus the total of gaseous water, and this last total influences the subsequent rain flow and thus the total of water in the liquid state. Then they are drawn to the attention that this loop is also present in money, as the amount of cash affects the flow of investment in long-term assets and thus its total, and the subsequent use of these long-term assets influences the subsequent future cash flows and thus the total of cash. Cognitively, in the end of the presentation it is finally highlighted and demonstrated that the financial statements

are all interconnected and that the properties of the water cycle can also be verified in the business cycle, as stated in Figure 3.

FIGURE 3

Table 1. Descriptive statistics of the dependent variable (LEARNING)

Variables	N	Min	Max	Mean (SD)	N G1	N G2	Mean G1*	Mean G2*	*t*-Value	*p*-Value	Cronbach's alpha
LEARNING	170	0	15	8.919 (3.767)	84	86	9.613	8.241	2.408	0.017	0.773

LEARNING is the grade obtained in 15 of the 20 questions (those related with the financial statements) of the mid-term exam of the introductory financial accounting course.

* Group 1 (G1) represents the students who attended the revision class using the SD' concepts introduced through analogies; Group 2 (G2) represents the students who attended the standard revision class.

Table 2. Descriptive statistics of the individual variables relevant for learning

Variables	N	Min	Max	Mean (SD)	N G1	N G2	Mean G1*	Mean G2*	*t*-Value	*p*-Value
LEARN_S	170	2.6	6.8	4.911 (0.804)	84	86	4.814	5.005	1.551	0.123
CLARIF_S	170	3.0	7.0	5.616 (0.735)	84	86	5.516	5.713	1.760	0.080
SELF_EF	170	2.7	6.6	4.803 (0.706)	84	86	4.729	4.876	1.362	0.175
INTRINSIC_V	170	3.0	7.0	5.499 (0.742)	84	86	5.433	5.564	1.151	0.252
PERF_O	170	3.5	6.9	5.486 (0.667)	84	86	5.466	5.506	0.390	0.697
LEARN_O	170	3.9	7.0	5.664 (0.680)	84	86	5.621	5.706	0.823	0.412
ANXIETY	170	1.5	7.0	4.772 (1.047)	84	86	4.699	4.843	0.186	0.373
MAN_CHECK_ANALOG**					84	86	6.740	2.780	-15.934	0.000

LEARN_S is a measure of the general learning strategies, CLARIF_S is a measure of the clarification strategies for learning, SELF_EF is a measure of the self-efficacy, INTRINSIC_V is a measure of the intrinsic value of the course, PERF_O is a measure of the performance objective orientation, LEARN_O is a measure of the learning objectives orientation, and ANXIETY is a measure of the students' anxiety.

* Group 1 (G1) represents the students who attended the revision class using the SD' concepts introduced through analogies; Group 2 (G2) represents the students who attended the standard revision class.

** MAN_CHECK_ANALOG is a variable that measures the perception of the students regarding the use of analogies. This variable was computed based on a question (with a 7-point Likert scale) that was answered by the students in the revision classes.

Table 3. Regression results

	C1	C2	C3
Intercept	8.241	6.785	4.951
SD_ANALOGY	1.372**		1.533***
LEARN_S		0.085	0.167
CLARIF_S		0.331	0.456
SELF_EF		0.953*	1.02**
INTRINSIC_V		-0.474	-0.434
PERF_O		-0.575	-0.596
LEARN_O		0.677	0.563
ANXIETY		-0.586**	-0.546*
Adjusted R2	0.028	0.048	0.084

Dependent variable: LEARNING, the grade obtained in 15 of the 20 questions (those related with the financial statements) of the mid-term exam of the introductory financial accounting course.

Main independent variable: SD_ANALOGY, a dummy variable that assumes 1 if the student attended the revision class using SD concepts introduced through analogies and 0 otherwise.

Control variables: LEARN_S, a measure of the general learning strategies; CLARIF_S, a measure of the clarification strategies for learning; SELF_EF, a measure of the self-efficacy; INTRINSIC_V, a measure of the intrinsic value of the course; PERF_O, a measure of the performance objective orientation; LEARN_O, a measure of the learning objectives orientation; and ANXIETY, a measure of the students' anxiety.

*, **, and *** indicate significant coefficients at the 10%, 5%, and 1% levels, respectively.

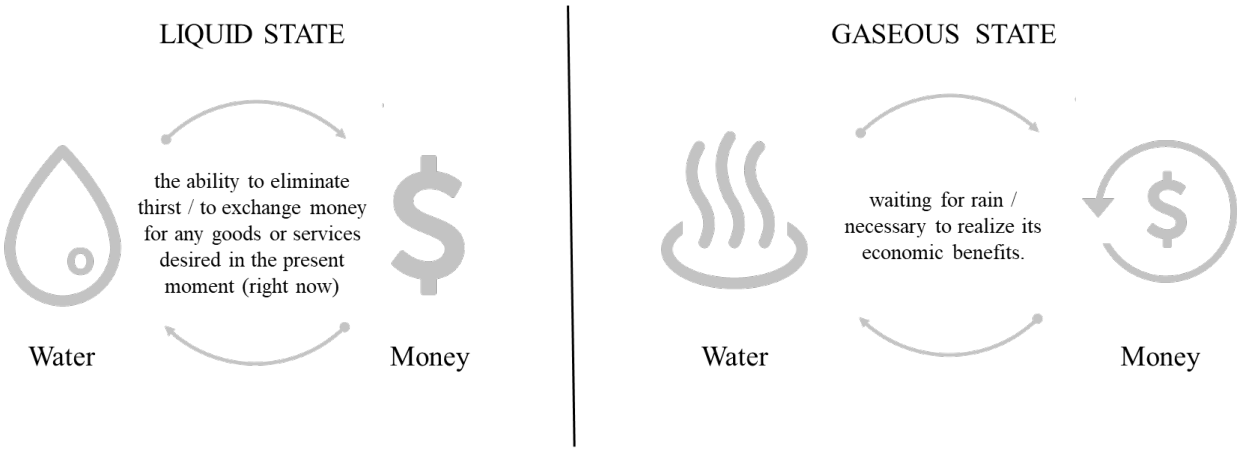

Figure 1 Caption: The analogy between two states of water and the two “states” of money

Figure 1 Alt Text: The two similar images placed side by side establish the analogy between water and money. On the left side, the analogy between water and money in their liquid states is presented, highlighting the common ability to eliminate thirst or exchange goods and services in the present moment. On the right side, the analogy between water and money in their gaseous states is presented, emphasizing that both require the passage of time either to rain or to realize the economic benefits.

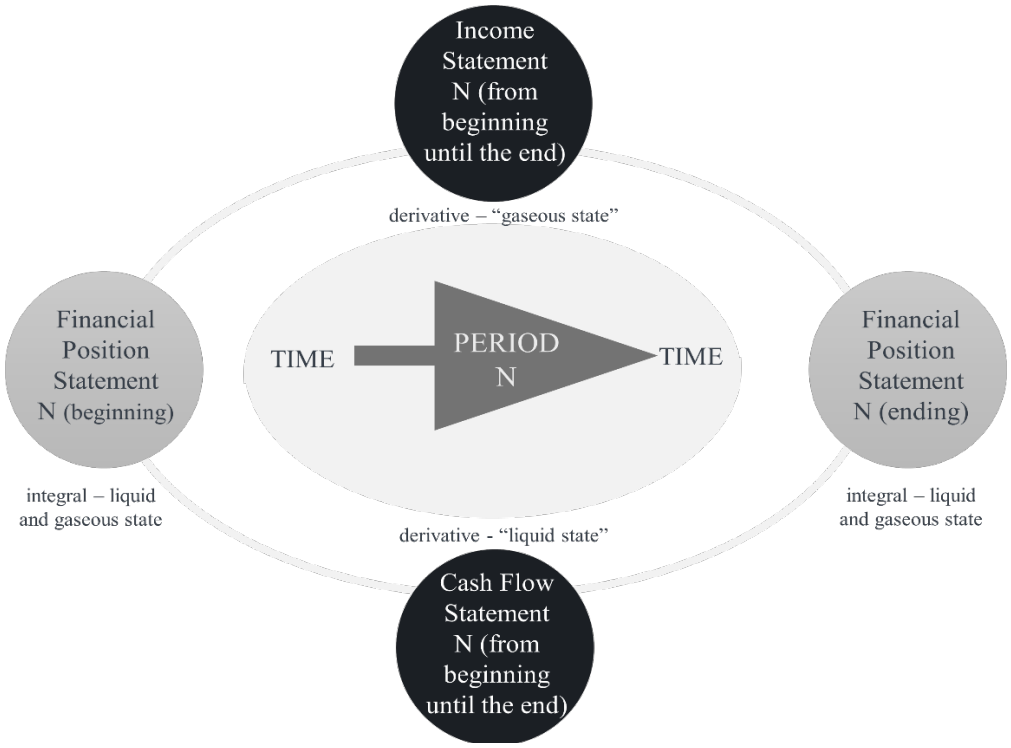

Figure 2 Caption: Financial Statements and the reporting cycle

Figure 2 Alt: The reporting cycle is described with a timeline ruler that shows in its end points two financial position statements, one for the beginning and another for the end of the reporting period. The changes between these two positions can be explained by two set of impacts, shown along the period above and below the ruler. They can be either economic effects (gaseous state) that occurred during the period, presented in the income statement, or financial effects (liquid state), presented in the cash flow statement.

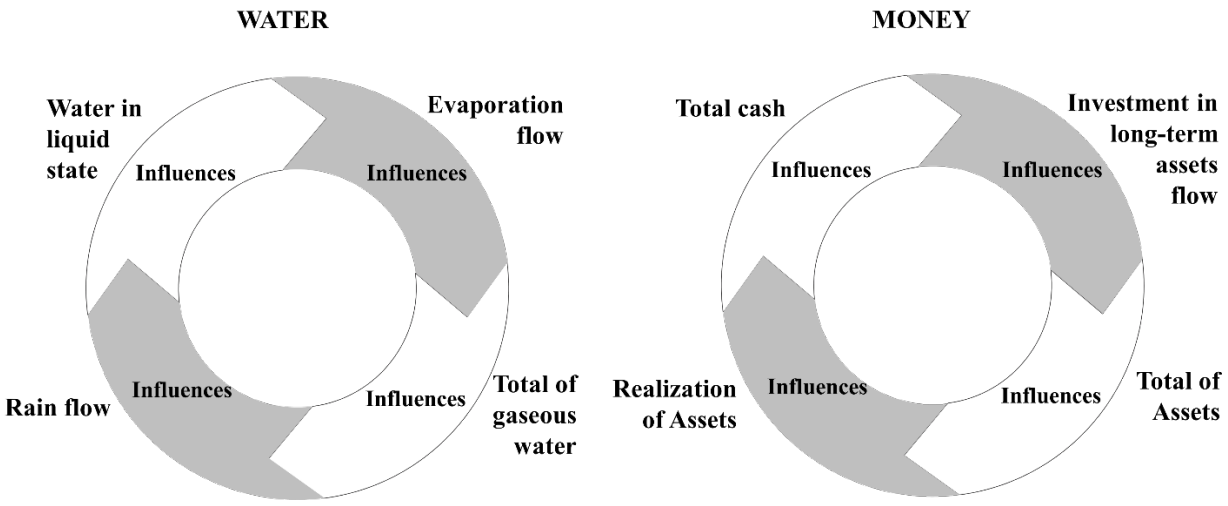

Figure 3 Caption: The analogy between the water cycle and the business cycle

Figure 3 Alt Text: The two similar images placed side by side establish the analogy between water cycle and money cycle. On the left side, a circular process shows that the quantity of liquid water influences the evaporation flow, that influences the quantity of gaseous water, that consequently influences the rain flow, which will finally contribute to the total of liquid water. On the right side, the circular process shows that the quantity of cash influences the flow of investment in long-term assets, which increases the total amount of assets, that when explored will increase the total amount of cash. In both cases, the flows and total quantities, and the various states, influence each other.