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Better Performance in Mathematics, Using Learning Styles While Learning Computational Thinking?

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Abstract—**The objective of this paper is to reveal the leading types of profiles addressed by researchers in the literature so that, exploring the possibility of including the most effective learning style, we contribute to help improve primary school children's learning by embedding computational thinking into mathematical context.**

We prepared a set of Research Questions related to the use and exploration of children's profiles such as; inquiring about the types of profiles investigated, the occurrence of each profile, and the experiments' conditions.

The analysis of the selected papers led us to see a lack of interest in investigating learning profiles in primary education. We did not come across any study working on developing the child's learning styles using computational thinking. Our recommendation is, and according to the proper authors of the learning styles' tests, to not use the actual tests that we encounter in the literature as they are designed because they were initially designed for the adult public. We would have to find another way to assess the learning styles of young primary school students; other than the one based on "self-assessment".

Keywords— abstraction; basic learning; computational thinking; elementary education; learning styles; mathematics; primary education; STEM

I. INTRODUCTION AND RELATED WORK

Society, teachers, family, and neighbors have a significant impact on shaping the learners' minds and behavior. Therefore, depending on the relationship that exists between the learners and these educational actors, each one of them has an impact on them, on their perception, worldview, personality, and profile, and how they perceive the information from the outside world [1], [2].

Inside the school walls, when addressing the relationship between the learners and the teacher, and to fulfill it, we found article 6 [3] among the general objectives of basic education that quotes: "(...) reading, writing, calculation, the acquisition of basic notions of culture, and the habit of coexistence as well as the study and work habits, the artistic sense, creativity, and affectivity, to ensure an integral formation that contributes to the full development of the student's personality, and to prepare them effectively for Compulsory Secondary Education. (...)". The innate goal of learners is to develop their potential in school. And the role of the school is to help stimulate that desire.

An instrument that could be used, to improve the above-mentioned learner-teacher relationship and to satisfy the learner's goal is to understand better the learner in our classroom, hence our interest in "learning styles". A learner's profile is a tool that helps the educator to build a relationship with his audience. In the perfect case, there would be a database where information, that concerns all learners, is stored. From the personal and family data (i.e. Name, family situation, social situation), pointing out how the student likes to learn, aspirations and passions, to the skill set of each one (i.e. skills, strengths, struggles).

We are contemplating in this article the following definition: the way the learner prefers to do things related to learning; the way he perceives the incoming information and the way he could reinforce his learning. It is how the learner does it, and also the factors influencing his learning and retention [4], [5], [6], [7].

That being said, we have to mention that two conflicting major theories stand out. The first one is in favor of the utility of exploring learning styles. The second is against it and affirms that this theory does not have a scientific basis [8], [9], [10]. This part will be developed in the related work section.

About the research method, we chose the Systematic Mapping Study (SMS) approach. We launched its execution following the guidelines [11] applied to our case

study. We explored the results of the analysis and described the clusters of papers we identified by presenting a study map.

In this paper, our target population is children who attend primary school classes and do not have learning disabilities, developmental delays, or intellectual impairments. To help both the student and the teacher fulfill the objective of a teaching-learning relationship which helps the learner enhance his abilities. We are going to contribute to exploring the possibility of using learning styles.

To elaborate on the state-of-the-art of a specific topic, we use knowledge synthesis methods. One of two forms is performed; a Systematic Mapping Study (SMS), also known as a scoping review. It provides an overview of a research area identifying, assessing, and quantifying the existing evidence on a topic. It aims to build a classified and categorized scheme of the field of interest. The second form is a Systematic Literature Review (SLR) a methodology used to aggregate all relevant evidence of a specific research question (RQ) by selecting primary studies.

Those methodologies gather a set of articles around a specific topic by collecting, selecting, and synthesizing those articles. Both of them are aiming to do a qualitative review of the available primary studies. The difference is that, while the assessment of the informal one is not specified, the systematic review uses a methodological process to collect, select, analyze, and interpret the existing evidence on a specific topic. This process can be arduous, especially when the researcher faces a large volume of primary studies [12].

Since we did need to identify what evidence was available and had been explored in the field of learning styles in primary education, we opted for an SMS. Moreover, to the best of our knowledge, we have not found any other SMS published dealing with profiles and learning styles.

The rest of this paper is organized as follows. Firstly, we briefly present the research methodology, results, and discussion. Finally, we identify the research opportunities and close with conclusions.

II. MATERIALS AND METHODS

The goal of this section is to expose the step-by-step process used to conduct this research. Since we were aiming to provide a large range of available literature related to our research topic, we used a form of LR (Literature Review), namely Systematic Mapping Study (SMS). Figure 1 describes the stages of the selection process.

A. Define Research Questions

The main research goal of this mapping study (following guidelines [11], [13]) is to identify and classify the profiles and learning styles that have been explored in primary education and assess the impact of the use of profiling in classrooms. We have deliberately addressed a large main Research Question and it is formulated as follows:

What impact has been reported about using learner profiling in primary education?

The objective of the study is broad enough to allow us to derive these 5 Research Questions from the research space:

RQ1: What are the different learning profiles encountered?

RQ2: What are the criteria commonly used in the different studies of each profile?

RQ3: How is the number of publications, by year, concerning the study of profiles in primary education? RQ4: What are the conditions of the experiment?

RQ5: What are the conclusions to be made regarding these results?

To the best of our knowledge, there is no such study published with the research questions presented above. In the following section, we present the string search used and the selection protocol that was followed.

B. Developing the Revision Protocol

Since we value the importance of an adequate String Search (SS), knowing that it is the key to extracting relevant studies, and achieving a suitable set of keywords to cover all the elements invoked by our research questions, rigorous work has been done on the definition of the SS. Addressing the search procedures, a 2-step search was used: an automated search and a manual one. This procedure is supported by Kitchenham [14] so that we could obtain a broader list of useful studies.

Our string search went through multiple changes. By respecting the strategy performed/suggested by Del Pino-Casado [15] we went from the RQ to prepare the SS:

("types of profiles" or "profile type" or "learning styles" or "personality profiles"or "personality") and ("Elementary school" or "primary school") and ("param- eters" or "profiling" or "profiling tools")

1) Automated Search

The SS was performed on the major search engines for academic studies such as Science@Direct, Wiley Online Library, SCOPUS database, IEEE Digital Library, ACM Digital Library, SPRINGER database as well as ERIC.

After performing the search for publications in conferences and journals using digital libraries and reading them, we noticed that known publications had not been included in our results list. Considering the narrowed number of papers gathered, we decided to perform manual research and extend the research to as early as 1970.

2) Manual Search

The manual search targeted 2 digital libraries, ERIC EBSCO host and Google Scholar. The selection process was similar to the one used in the automatic search. The reason why we chose to perform a manual search on the ERIC digital library is that ERIC uses intuitive discovery tools and combines terms in a way that reduces the need for quotation marks or advanced search logic and we obtained 9 papers on Google Scholar.

In conclusion, the selection process typically follows steps: The 1st is based on keywords, the 2nd by title, the 3rd by abstract, and the 4th process of reading; Abstract, Introduction, and Conclusion (A+I+C).

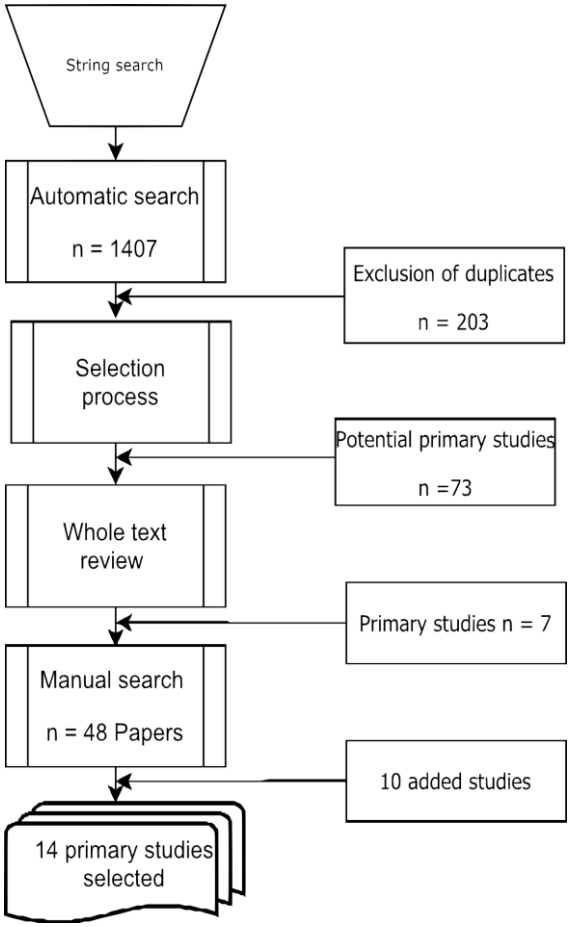

Figure 1: Description of the full process of selection of primary studies.

To support the extraction of data from the papers,

- We used the reference management system: Mendeley https://www.mendeley.com.
- And some spreadsheets were created to support the paper selection process in the stage of inclusion and exclusion criteria application.

III. RESULTS AND DISCUSSION

In this section, we are going to address the main research questions, our observations, and findings, highlighting the evidence gathered from the data extraction process. Having established that there was a need for such a review and that no other review had been published in this area, we proceeded to conduct the mapping study.

RQ1: What are the different learning profiles encountered?

This question encloses 2 more questions; the first one is more general than the second one. By these questions, we seek clarification on, first, the types of profiles discussed in the literature in primary teaching, and then we intend to examine the studies having considered learning styles with computational thinking [16], [17] used to improve mathematical skills [18]. It is visible that the emphasis is on studies treating "Achievement profiles" and "Reading motivation". Other profiles are evoked such as "creative profiles" and "Gifted profiles". Articles [19], [20], [21], explored these learning profiles, especially with primary teachers, and concluded that the 2 most adequate profiles to deal with mathematical and science problems are convergers (have the ability to solve problems and make decisions based on finding solutions to problems and prefer careers in medicine and engineering) and assimilating (are more interested in ideas and abstract concepts and tend to specialize in mathematics and basic sciences) [22], [23], [24], [25]. Converging profiles score better in mathematics than the other profiles [26].

On another note, research has demonstrated that many students perform poorly in mathematics and tend to ignore the subject altogether. Among other reasons, this is what led us to take an interest in mathematics in the first place. This might be explained by mathematics anxiety [27] and gender [28]. In relating it to the achievement profiles cited above, the findings of the article showed that the performance of students having assimilating or converging learning style score better on TIMSS (Trends in International Mathematics and Science Study) items [20], [24],. Moreover, they get even better as the complexity of the questions increases. In this article where the association between learning styles and science achievement was examined, among the results announced is that abstract conceptualizing was correlated with high scores of achievements.

The "big five personalities" have also been addressed, especially in study S14, which investigated the relationship between the rate of CT's development and the factors of the "Big Five" model. For this matter we only encountered one study treating learning styles applied to the CT field, maybe it is because CT is a yet-to-be-developed field. Authors affirm, by the results obtained from the study and based on the literature, that CT has indeed a non-cognitive side that should be taken into account; results showed that a significant correlation between CT and self-efficacy was found.

Finally, we noticed research gaps concerning socio-economic profiles, Kolb's Learning Profiles (LSI: Learning Style Inventory), and VARK learning styles [29].

RQ3: What are the publication trends, by year, about the study of profiles in primary education?

This question aims to identify and measure the interest of researchers in studying profiles in primary education. The first identified paper is a conference paper presented by Charles M. Hunter of the Bureau of Evaluation – Louisiana Department of Education [30]. In the year 2013, we identified the majority of the papers.

In addition, we noticed the existing "gap" between 1987 and 2008: there was no investigation concerning learning profiles in primary education in that time frame. We did not find any referencing between the encountered papers. The type of venue mostly targeted by authors is "journal article" with a percentage of 84.6, 7.7% for "conference paper" and another 7.7% to "report".

RQ4.1 How were the tests conducted?

This question is intended to highlight the testing strategies adopted by the researchers. We would like to know the strategies and means used to conduct the tests: a questionnaire, an interview, relying on observations, or using software. According to the results, the process has not been automated, and measurements are still done manually.

Regarding the use of different tests, in most cases, more than one type of test is being used (known, personalized, revised, automated tools).
Among the known tests used: the Visual Motor Integration (VMI), the Wide Range Achievement Test (WRAT), the Clinical Assessment of Behavior–Teacher (CAB-T), the self-regulated learning (SRL), the Index of Learning Styles (ILS), among the Revised tests used: The WISC-R (Revised), the Fruit Stroop task, emotional engagement from Eccles and Wigfield, the cognitive engagement test from Frenzel, Dicke, Pekrun, and Goetz. 38.46% of the studies used known tests with 26.92% using revised tests which are tests that are known but for some reason (e.g.: translation into Mandarin Chinese) it has been adapted or revised.

RQ4.4 What software is used to do the profiling?

Answering this question gives us an idea concerning the software used for this matter. Another important result is that only one investigation is using a computerized process and it is optional. The tool is not open and belongs to Alberta Education.

Only Alberta educators are granted special permission to reproduce parts of this document that do not contain excerpted material. So, it is not reproducible. ICTs (Information and Communication Technology) were only used in 1 study out of the 14 selected studies; besides it was optional. As we are in the era of the latest technologies, it would be better to exploit them so that they facilitate the different processes of collection and treatment.

Based on our research and the result of this review, we note that there is an absence of methods for evaluating Learning Styles in elementary school [31], [32].

We hypothesize that by learning computational thinking, learners are to develop their mathematical skills. And as part of our experiment, we would like to explore the learners' learning styles.

With that said, and as mentioned in a previous article, there have been a lot of definitions of CT, we are to adopt the components, and the best known and cited: abstraction, algorithm, evaluation, decomposition, and generalization. We explored a review conducted between 2006 and 2017 [33]. It was noticed that there is a growing interest among the scientific community in exploring the relationship between CT and Maths. From the 42 examined articles, only 8 papers have considered working on this topic, at the educational level we are interested in, and they chose to use programming to teach CT. So, there has been an interest in embedding CT into math and science contexts which proved to be productive in mathematical understanding because of the interplay of the fields [34]. Also, in engaging young mathematicians in some ideas of group theory using a combination of hands-on and CT tools.

IV. Conclusion and Future Work

Our study has illustrated several areas in which further investigation would be useful, especially regarding evaluation and validation. First and foremost, our findings show that not enough investigation is done in primary education about the exploitation of learning profiles. Since we are interested in VARK learning styles, we encountered a poor number of works done regarding this instrument, in this context, despite having authors affirming their existence. We suppose that it is because of the emergence of the opposite current and the need for good-quality investigation in this field. Results from the literature, mentioned in the related work section, support that learning styles are unreliable and have a negligible impact on practice. Nevertheless, the fact is grey literature is consuming this subject very broadly.

We noted also that there was too little focus on using ICT (Information and Communication Technology) during the profiling process. The introduction of ICT tools could support the objective side of data collection. Also, because of CT's cognitive side, there is a need for studies about learning styles.

The work stands on an interest in basic learning because of the low performance in this area (especially mathematics) for a long time. "To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability" [35]. And that bringing computational thinking into mathematics would enrich it. Many factors are helping to build this negative attitude toward this particular subject. As we are working in the field of Computer Engineering, the goal is to contribute to helping students elevate their mathematical performance, and for that, we would like to explore the path of computational thinking (CT). Recent articles confirm that there is a link between CT and mathematics indicating that computational thinking and mathematics learning have a reciprocal relationship and are described as "mutually supportive". Additionally, CT has a historical connection to mathematics education and a foundational connection to mathematics. Finally, we are to take into consideration the fact that "(…) computational thinking describes the mental activity in formulating a problem to admit a computational solution.". Our objective behind this paper was to establish if our children's profiles are taken into account and given any importance while educating them in primary school. Throughout the study, we intended to bring some clarifications and test the possibility of using certain types of learning styles related to mathematics. Combining the two perspectives, we would like to continue exploring this path by focusing on the cognitive side of CT and exploring the learning styles.

In consideration of the foregoing, we do not want to enter into this conflict of whether the effectiveness of learning styles exists or not. Based on our research and the result of this review, we conclude that there is an absence of methods for evaluating Learning Styles in elementary school. Our recommendations for education administrators are as follows:

- To encourage further investigation into the exploitation of learning profiles and to not work with the current tests as they are now because, as the test authors state, those are not made for a young audience but rather for adults.
- To consider using ICT tools when profiling students. This will enhance data collection and support objective assessment.

- To develop methods, approaches, and tests that do not rely solely on self-evaluation (used in the studies we encountered).
- To address achievement gaps and ensure diversified content, regardless of the student's learning style.
- To encourage interdisciplinary approaches that explore the potential of CT in math and STEM contexts.

Our future work will be focused on basic components (and if time permits investigate the rest) and skills that favor dealing with mathematics in particular (and STEM in general), attaching the result to increasing achievement so that no child would be left behind.

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