

# Learning Styles in Programming Education: A Systematic Mapping Study

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**Abstract**—The interest on effective strategies to improve the learning process increased over the years. The usual practice is to know the characteristics of a student and how those can affect the learning style. The style describes how learners collect, select, interpret, organize and store information. This paper overviews the application of learning styles and how those affect the teaching of introductory programming. We performed a systematic mapping study to improve our knowledge about student characteristics in the teaching of programming. Twenty-one papers were relevant for our research. The main findings are: i) the Soloman-Felder Index is the most used model of learning style; ii) studies focus on the effects of learning styles on student performance; iii) instructors apply active approaches to motivate a different kind of learners. We conclude that learning style does affect a student's ability to learn. For this reason, teachers should incorporate those styles into their pedagogical material to cater to the majority of students needs.

## I. INTRODUCTION

The interest on effective strategies to improve the learning process increased over the years. The usual practice is to know the characteristics of a student and how those can affect the teaching and learning process. The learning styles describe how learners collect, select, interpret, organize and store information[1]. They serve as relatively stable indicators of how students respond to the learning environment[2].

In introductory programming courses (IPC), there is a continuous effort to reduce the freshmen students difficulties as well as to find ways to decrease the failure rates. Understand how learning styles can contribute to IPC is the focus of this paper. We performed a study to improve our knowledge about student characteristics, difficulties, and abilities in the programming education. This study describes a systematic mapping study to overview the use of learning styles in IPC in the last ten years. The following research questions guided our study:

- **RQ1:** What are the models of learning styles used in the introductory programming education?
- **RQ2:** How are used the learning styles in the introductory programming courses?

These research questions guided the steps of our study. We searched for relevant papers at six scientific databases. The searching process retrieved a total of 4321 documents. After, we analyzed and filtered twenty-one as relevant papers for our research.

Our main findings are the following: i) the Soloman-Felder Index is the most used model of learning style; ii) studies focus on the effects of learning styles on student performance; iii) instructors applied active approaches to cater a different kind of learners. The results point out that learning style affects the ability to learn, however, it can not be considered a success or a failure indicator. We concluded that teachers should incorporate these styles into their pedagogical material to cater to the majority of students needs.

The remainder of this paper is organized as follows: Section II presents the related works. Section III details the employed research methodology, followed by the presentation and discussion of the results in Section IV. The validity threats are discussed in Section V. Finally, Section VI presents the conclusions and future works.

## II. RELATED WORK

In this section, we summarize three relevant literature reviews we found on learning styles.

- Vicki [3] investigated the implications of learning-styles-based teaching and concluded that learning style can not be considered a successful indicator. She suggested that teachers evaluate learners' success by their performance and attitudes, not only by their characteristics;
- Coffield et al. [4] present an evaluation of the major models of learning style. They aim to understand the models' merits and deficiencies better. So, they investigated if there is empirical evidence that these models have an impact on the teaching and learning processes. They concluded that knowing how people learn can be used as a tool to enhance the learning. In that study, the Dunn model was mentioned as the most used learning style. Although, in our study, this model was not cited in any paper;
- Workman [5] reported the beneficial and controversial facts in accommodating the teaching method for the style of each learner. According to him, there are quantitative facts to disagree in adapting the teaching process to the learning style;

Literature reviews mentioned above are not focused on a particular area. We did also not find any literature review that related learning style and programming education. For this

reason, we aimed to explore the relationships among both of these topics.

### III. RESEARCH METHOD

In this section, we detail the steps performed in systematic mapping study. In this method, researchers provide a classification scheme and structure a field of interest [6]. Petersen suggested a process which has five main steps: (i) definition of research questions; (ii) conducting the search; (iii) screening of papers; (iv) key-wording of abstracts and (v) the data extraction. These steps are detailed below.

#### A. Definition of Research Questions

We defined two research questions to achieve the goals of this study.

- **RQ1:** What are the models of learning styles used in the introductory programming education?
- **RQ2:** How are used the learning styles in the introductory programming courses?

RQ1 aims to describe the most used models and how to measure the learning styles of novice programmers. The answer of RQ2 reports how they can influence the teaching in the programming education context.

#### B. Conduct Search

In this section, we set up the strategy to design a suitable search string. We were guided by the following suggestions of Kitchenham et al. [6] with the purpose to decrease bias:

- Identifying of relevant concepts in research questions;
- Finding out an alternative spelling, abbreviations, and synonyms for these keywords;
- Checking subject headings in relevant journals and conference proceedings;
- Using boolean operators OR to connect the synonyms;
- Using boolean operators AND to connect the other terms;

We selected the keywords *learning style*, *introduction* and *programming* to perform some exploratory searches. Next, we find out synonyms for these keywords. Finally, we established the following final string to be used in the automatic search:

**(learning style AND programming) AND (beginner OR novice OR introductory OR freshmen)**

We chose scientific databases that provide tool or mechanism to perform automatic searching and have relevant sources in the computing education area. We selected the following scientific databases: ACM Digital Library[7], IEEEExplore[8], Scopus[9], edITLib[10], Science Direct[11] and Springer[12]. After, we used the automatic searching tool to conduct the search. Table I shows the number of papers retrieved by each database.

This step was done from November 15th, 2016 to February 1st, 2017 and a total of 4321 documents were found.

Table I  
AMOUNT OF PAPERS RETRIEVED BY SEARCH

Database	Retrieved	Relevant Papers
ACM Digital Library	17	10
IEEEExplore	13	0
Scopus	100	7
EdITLib Digital Library	341	0
Science Direct	436	4
Springer	1366	0
<b>Total</b>	<b>4321</b>	<b>21</b>

#### C. Screening of Papers

The definition of inclusion and exclusion criteria are a typical strategy to perform these screening. In our research, six criteria were created, three inclusion criteria and three exclusion criteria. They are listed below:

Inclusion criteria:

- **F1:** The title, abstract or keywords should explicitly mention the terms *learning style* and *programming*;
- **F2:** Study should be related to Computer Science;
- **F3:** The paper should be published not before 2006;

Exclusion criteria:

- **F4:** Work in progress;
- **F5:** Papers that are not reported in workshops, conferences or journals;
- **F6:** Documents whose full text is not available for free;

The documents previously found were used as input for this step. We applied criteria mentioned above to filter the relevant studies. We kept only one version of the document. So, duplicated papers were removed if indexed by more than one database. As a result, a total of 21 were considered as relevant papers.

Table I also shows the result of this screening process by each scientific database. There is no relevant papers from the databases IEEEExplore, EdITLib and Springer. IEEEExplore retrieved duplicate documents, or they did not mention the words in F1. Some of the documents in EdITLib are not available for free download (F6) whereas the majority of Springer papers is not related to computer science (F2). The database that had the best retrieval rate was ACM with 58.8% of relevant papers.

#### D. Keywording

According to Petersen et al. [6], keywording reduces the time needed in developing the classification scheme. When a set of keywords has been chosen, studies can be clustered,

Table II  
RESEARCH FACET TYPES

Category	Description
Experience Paper	It explains what and how something has been done in practice. It has to be the personal experience of the author and usually includes a lesson-learned section
Evaluation Research	Techniques are implemented in practice and an evaluation of the technique is conducted
Opinion Paper	It express the personal opinion of somebody about a certain technique
Solution Proposal	When a solution for a problem is proposed, the potential benefits and the applicability is shown by a small example or a good line of argumentation
Philosophical Papers	sketch a new way of looking at existing things by structuring the field in the form of a taxonomy or conceptual framework
Validation Research	Techniques have not yet been implemented in practice or the work was done in the lab

used to form the categories for the map and can help answer the research questions. In this step, we identified keywords that reflect the concepts and contribution of the paper and combined them to classify and understand the contribution of the research. So, we used the following criteria for the studies categorization:

- **Research Facet Types:** The research facet reflects the research approach used in the papers. This category are proposed by Petersen et al. [6] and are described in Table II;
- **Model of the learning style:** This category represents the model of learning style used to classify students. It can help us to answer RQ1;
- **Tool:** It represents the questionnaire used to measure the learning styles;
- **Teaching method:** This one represents the pedagogical strategies applied in the introductory programming courses.

#### E. Data Extraction

The data extraction helped us to answer the research questions. We read the filtered documents and, then, we retrieved a lot of information. After that, we stored the title, year of

Table III  
YEAR WISE DISTRIBUTION

Year	Studies
2007	[13]
2008	[14]
2009	[15], [16], [17]
2010	[17], [18], [19], [20], [21]
2011	[22], [23]
2012	[24]
2013	[25], [26], [27], [28]
2014	[29]
2015	[30], [31]
2016	[32]

publication, venue (forum or conference proceedings), author's name and location. Each one was assigned to a set of keywords and classified according to categories as mentioned above. In this work, none of them were assigned to more than one category from the same criterion.

## IV. RESULTS AND DISCUSSION

This section shows the results produced by the extraction of data from the primary studies according to the process described in Section III. To provide the simplest way to view the results, those were separated into two groups: general information and the research questions. Firstly, we present the overview of relevant studies through the general results. After that, the answers to the research questions are presented.

### A. General Results

In this section, we present general information about the relevant studies. We considered as general information the year of publication, the venue where they were published and authors information. The year wise distribution of the relevant studies is presented in Table III. The following patterns were observed in the result: the number of publications varies from 1 to 5 papers; 2010 and 2013 are the most productive years with 5 and 4 publications, respectively; 2009 had 3 studies; 2011 and 2015 with two and the years 2007, 2008, 2012 and 2016 with only one paper each.

The majority of the studies (81% - 17 papers) were published in conference proceedings, while 19% (4 studies) were journal papers[13], [15], [24], [32]. *Conference on Innovation and Technology in Computer Science Education (ITiCSE)* accepted the majority of the publications with three papers.

The countries of the researchers are displayed in Table IV. Results show that Malaysia and Australia are the leading countries with 4 and three studies each one. USA, United Kingdom, and Portugal had two studies and the other countries with one

Table IV  
COUNTRY WISE DISTRIBUTION

Author Location	Paper
Malaysia	[18], [24], [25], [26]
Australia	[22], [23], [33]
USA	[16], [32]
United Kingdom	[27], [31]
Portugal	[19], [20]
Argentina	[28]
Sweden	[30]
Finland	[17]
Italy	[14]
Hong Kong	[15]
New Zealand	[29]
Thailand	[21]
United Arab Emirates	[13]

Research Type Facet

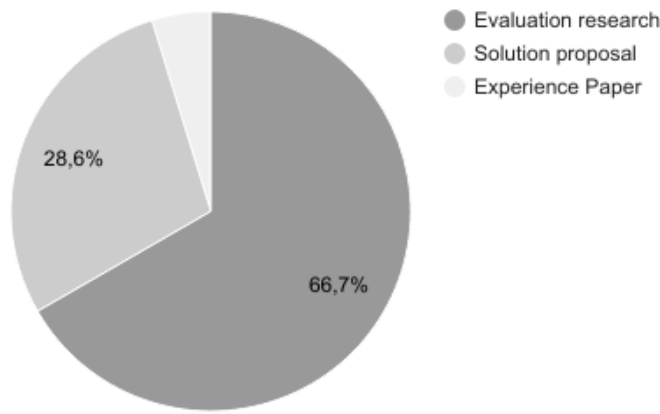


Figure 1. The Research Facet Type of Selected Studies

study. Anabela Jesus Gomes, Antonio José Mendes[19], [20] and Bedour Alshaigy [27], [31] are the most prolific authors with 2 papers each.

Figure 1 shows the papers distribution according to the classification scheme described in Table II. 66.7% of studies were classified as evaluation research, and 28.6% of them were classified as solution proposal. The rest of them (4.7%) was categorized as experience paper. Philosophical papers, opinion paper, and validation research papers were not found in the selected studies.

## B. Answers to Research Questions

In this section, we present the results grouped by the answer to research questions.

### • RQ1: What are the models of learning styles used in the introductory programming education?

The literature reports 71 types of learning styles. Some of them have been used whereas others have fallen into obscurity. Here, we outline the models of learning styles most used in programming education.

There are 11 papers that used **Soloman-Felder Index** as the model of style [13], [16], [17], [18], [19], [20], [21], [24], [29], [31]. This model categorizes four different dimensions of an individuals learning style: active/reflective, sensing/intuitive, visual/verbal, and sequential/global. *Active* learners prefer an environment that enables them to learn to do something active like applying or discussing it with their peers. *Reflective* learners prefer an environment that enables them to think about something quietly first. *Sensing* learners prefer learning facts and concepts, *intuitive* learners prefer learning by discovering possibilities, applications, and relationships. *Visual* learners prefer learning from material they can see, they prefer the use of pictures, diagrams, flowcharts, and demonstrations. *Verbal* learners prefer words, either spoken or written. *Sequential* learners follow material in a step-by-step sequence and gain understanding in linear steps. *Global* learners tend to learn in large jumps [34].

**VARK Modalities** is an acronym for Visual (V), Aural (A), Read/Write (R), and Kinaesthetic (K). This model defines four learning styles: *visual* is a learner that learns best by seeing, similar to visual Learner previous mentioned; *Aural* is a student that learns best through listening to lectures, and it is similar to verbal learner; *Read/Write* is a student that prefers to learn reading textbooks and then summarizing or writing what they have understood; *Kinaesthetic* students learn most effectively through experience by undertaking experiments, and carrying out case studies, practical sessions, etc. [35], [36]. This model was used in two papers [22], [26].

There were two models mentioned by one paper: **Perkins' model** and **Gregorc Style Delineator** (GSD). Perkins suggests the classification of novice programmers' as stoppers, non-starters, movers, and tinkerers. *Stoppers* are students who tend to stop or give up when they can not immediately know the solution to a problem. *Non-starters* are a type of stoppers who makes some progress in exercises but do not submit their programs for assessment. *Movers* try different approaches when faced with a problem. *Tinkerers* make changes, but using a random approach. Cardell [23] applied this model to categorize novice programmers.

In the GSD model, there are two mediation abilities with two qualities which result in four styles: concrete sequential, concrete random, abstract sequential and abstract random[37]. *Concrete sequential* learners tend to perceive reality through their physical senses and to think sequentially. *Concrete random* learners like to think intuitively, instinctively, impulsively and independently. *Abstract sequential* learners are logical

Table V  
MODELS OF LEARNING STYLES

Model	Studies
Soloman-Felder	[13], [16], [17], [18], [19],
Index of	[20], [21], [24], [28], [29]
Learning Style	[31]
VARK	[22], [26]
Modalities	
Perkin's	[23]
Gregorc Style	[15]
Delineator	
No mention	[14], [25], [27], [30], [32] [33]

and analytical individuals who have a preference for mentally stimulating tasks and environments. *Abstract random* learners tend to think in a nonlinear and emotional manner. This model was mentioned in [15].

Learning styles are measured based on the answers of the learners to a questionnaire. In general, they have to choose responses suitable for particular occasions. The style is identified according to the student responses. Each model has a specific inventory. The Index of Learning Styles Questionnaire was formulated by Richard M. Felder and Barbara A. Soloman to measure the styles according to Solomon-Felder Index [38]. This questionnaire has 44 questions whose answers can be submitted, and the results are automatically sent via the Web [39]. The VARK Questionnaire intends to report the learner's experience to measure their learning styles [35]. It is a free questionnaire and available online.

Five papers did not mention which model of learning style was used.

The answer of RQ1 is schematized in Figure 3. It shows the relation between research facet types and the models. As aforementioned, the majority of the papers were categorized as evaluation research. These studies reported an application of a teaching strategy and evaluated those effect on the learning styles. A solution was proposed in six of them, three using the Solomon-Felder Index and others three papers did not mention any model.

#### • RQ2: How are used the learning styles in IPC?

In general, the majority of studies explored if learning style affects the student performance in introductory programming courses. However, there is no consensus about this question. According to [20], there is no correlation and no pattern

Degree Education Level

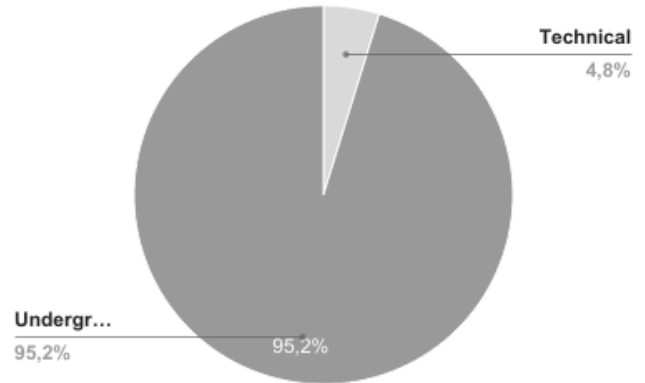


Figure 2. Educational Stage

of the students that have better or worse academic results. Conversely, studies [17], [22] suggest that the reflective students were better in programming than active. Additionally, Raadt [22] also reports that verbal learner outperformed visual learner. Other study compared the profile of programming and mathematics students [16]. We concluded that the learning style can not be used as an instrument to predict student success.

On the teaching strategies, some of the studies reported the beneficial for adopting pair activities. Student improves learning when they verbalize their thoughts to someone. It also happens when they were pairing to a learner with a different style. For this reason, the majority of the studies applied strategies based on an active method. The most used are pair programming, peer discussion, collaborative and cooperative learning. Some researchers [18], [24], [25] reported the use of pair programming and peer discussion as strategies of teaching to encourage students to be more engaged. Moreover, [16] suggested the incorporation of more active, sensing, and visual learning style practices into the teaching process.

Raadt and Simon [22] compared the relation between the learning style of students with the learning style of their instructor. They report that students with profiles that matched those of the instructors tend to perform better than others. Authors also suggested that is unwise to assume that students share the same learning preference as their instructors. Some instructors are teaching according to their preferences. If the learning materials are designed to cover both read/write, and kinaesthetic profiles will suit all students. So, when dealing with it, it should be a good textual material to suit read/write modality and hands-on experience to suit the kinaesthetic.

Finally, Figure 2 shows that about 95 % of the studies target to undergraduate courses. While only one was driven to technical course [28]. Other educational stages were not mentioned in the studies.

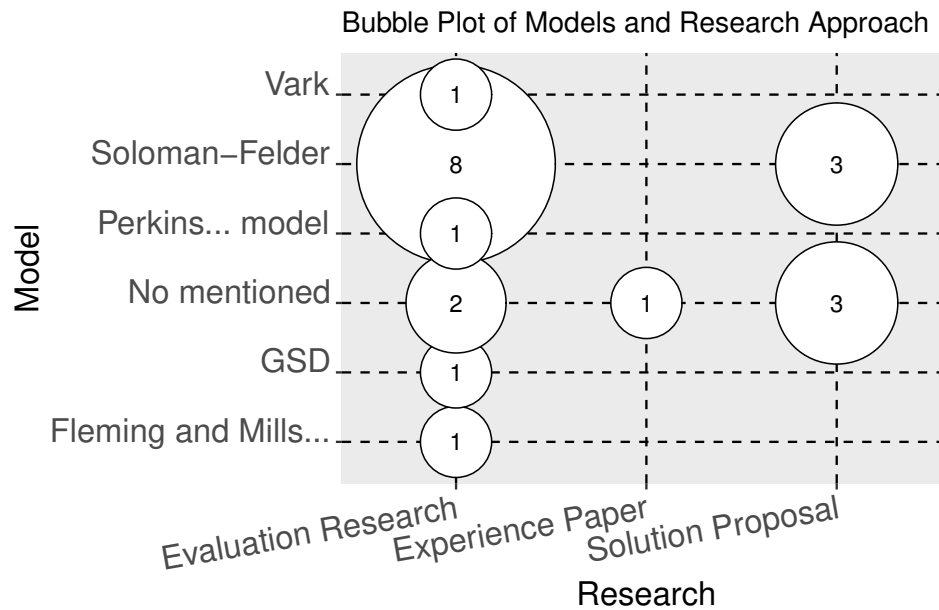


Figure 3. Visualization of a Systematic Map in the Form of a Bubble Plot

## V. THREATS

Although the systematic mapping is more accurate than other literature review approaches, it is still possible to enumerate some threats to its validity. This study does not have any statistical assumption what can mean a threat internal validity. The rate of retrieved papers can indicate that the terms used in the search process are suitable. Only 0.48% of the studies extracted were considered as a relevant paper. It happens because the term "learning style" is also applied to other research areas. Moreover, the data collected are limited by the automated searching engine from databases selected in this work. Therefore, the results can not be generalized.

## VI. CONCLUSIONS

This paper presents a systematic mapping study to overview the use of learning styles in introductory programming teaching. We summarized papers that were published from 2006 to 2017. For this propose, we defined research questions and search strings to guide the automatic search on six databases. After running the search, 4321 articles were selected. We filtered them based on the inclusion and exclusion criteria resulting in 21 studies. We defined classification criteria to help us answer the research questions. The majority were conferences proceedings papers. Furthermore, Malaysia is the leading country.

The main findings are the following: i) the Soloman-Felder is the most used model; ii) researchers mainly investigate the effects of LS on student performance; iii) and in most cases, instructors apply an active method in order to encourage a variety of learners. The results point out that learning style does affect a student's ability to learn. Nonetheless, it can not be considered as a unique factor of success or a failure.

Our interpretation of the study results has allowed us to identify some possible research opportunities:

- Propose, apply and validate active pedagogy concepts for undergraduate students in IPC;
- Evaluate the effects of active learning on student's motivation and interests in IPC;

## ACKNOWLEDGMENT

This work was partially sponsored by the agreement N<sup>o</sup> 08200.315131/2016-10 between UFCG and ePol/DPF.

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