A Quantitative Study of Publications about Underrepresented Minority Undergraduate Students in Computer Science Majors in the United States

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***Abstract*—This is a full research paper. Including underrepresented minority groups (URM) in the computing field has been a challenge in the United States for a long time. Specifically, African American, Hispanic/Latinx and native American students continue to have low participation in computer science majors despite efforts to include these groups in Computer Science majors in the United States. In this context, the paper presents the research question: What types of publications are there in the literature about activities focused on including underrepresented minority groups in Computer Science majors in the United States? URM in this paper means minority African-American, Hispanic/Latinx and Native American students. To answer this question, a systematic literature mapping process covering the last 15 years (2009-2023) was applied using four academic sources: Scopus, Web of Science, IEEE Xplore, and ACM Digital Library. The inclusion criteria were: documents published in a conference or journal; documents published in the period 2009-2023; computer science and education areas; documents focusing on underrepresented minority groups, specifically African American and Latinx/Hispanic and Native American; and documents concerning the undergraduate level. The exclusion criteria were: documents with less than four pages (an attempt to map only full papers); documents in a language other than English; documents that do not mention African American and Latinx/Hispanic; and documents from educational institutions outside of the U.S. We found 521 relevant papers about URM and CS majors, most of which were published at ASEE, FIE, and SIGCSE conferences. There has been an increasing number of papers published in these 15 years. In the last five years, 329 papers were found, representing more than 63% of all papers found in this literature mapping. The universities with the most publications were Florida University, the University of Texas at El Paso, and Purdue University. California, Texas, and Florida are the top three states which the highest number of papers. We classified the paper and found 48 papers for EDM (educational data mining), 163 papers for Educational Model, Report 37, Perception 105, and Program 198.**

***Index Terms*—URM, Minority, Computer Science, African American, Hispanic, Native American**

I. Introduction

Including underrepresented minority (URM) groups in the computing field has been a challenge in the United States for a long time. Specifically, African American and Hispanic/Latinx students continue to have low participation in computer science majors despite affirmation actions to include these groups in Computer Science majors in the United States. The lack of diversity in gender and race/ethnicity in Computer Science majors is a widely acknowledged challenge [1]–[3].

The broadening participation has been reported in different literature review papers on the subject of inclusion in STEM as [4]–[11]. The most recent systematic literature reviews either focus on women in computing [12], U.S. Latines in Computing [13] or K-12 students (including URM students) [14]–[16].

In this context, this paper presents a literature mapping about underrepresented minority groups, specifically African American, Hispanic/Latinx, and Native American, in Computer Science majors and addressing the following research question (RQ): What types of publications are there in the literature about activities focused on including underrepresented minority groups in Computer Science majors in the United States? To answer this research question, we applied a systematic literature mapping protocol. We used Scopus, Web of Science, ACM Digital Library, and IEEE Xplore; these academic databases are the most important venues in the CS area [17]. After applying the protocol, we found 521 documents (conference papers and journal articles), only in the United States, with a focus on URM in CS majors.

The differentials of the literature mapping presented in our paper are the focus on undergraduate students in computer science majors, the analysis of the last 15 years (2009-2023) of publications, different research questions, and the URM group, which is African/American, Hispanic and Native American students. Our research focuses on reviewing documented educational initiatives to increase retention of these URM groups in CS majors.

This paper is organized as follows: Section II describes the process applied for the systematic literature mapping; Section III presents the answers to the research questions; Section V presents the limitations; in Section VI the conclusions are presented.

II. Methodology

The methodology was based on the systematic literature mapping process by Kitchenham et al. [18]. The applied process is composed of four steps: define research questions,

select relevant papers, analyze the relevant papers, and answer the research questions. The first two stages are described bellow, Section III presents the results.

A. Define research questions

Computer Science majors with three research questions (RQ):

- RQ1 - What types of publications are there (conference, journal, year and states) about activities focused on including underrepresented minority groups in Computer Science majors in the United States?
- RQ2 - Which colleges/universities have published on this topic?
- RQ3 - What are the document types (report, perceptions, educational model, educational data mining, and others)?

B. Select relevant papers

The step,"select relevant papers," consisted of defining the search string, specifying the inclusion/exclusion criteria, choosing the digital libraries, and selecting the papers.

The process for defining the search string was composed of an initial string that was defined by the group of co-authors of this paper based on meetings, analysis of some papers on the topic and the use of Vosviewer [19], a tool to visualize bibliometric networks, to analyze the keywords. The search string is (Figure 1): *("computer science" OR computing) AND (urm OR hispanic OR minority OR underrepresented OR "african american" OR diversity OR ethnicity OR race OR latin OR women OR gender OR girl OR female OR black OR "native american" OR hawaii OR alaska OR "people of color") AND (student OR graduate OR undergraduate OR doctor OR phd)*. This search string includes doctor, PhD, and graduate because that is part of a bigger research project.

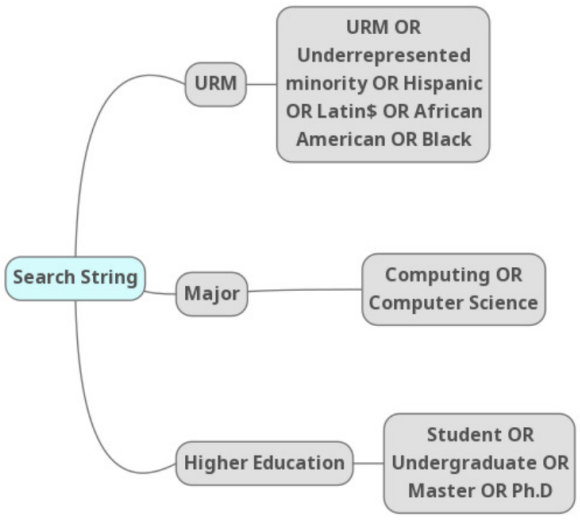

Fig. 1. Search String Groups.

The search string was applied to four academic sources, ACM Digital Library, IEEE Xplore, Scopus, and Web of Science. These databases have the most important publications in the Computer Science Education field [20].

The inclusion criteria (IC) were:

- IC1) Documents published in a conference or journal;
- IC2) Documents published in the period 2009-2023;
- IC3) Computer science and education areas;

The exclusion criteria (EC) were:

- EC1) Documents with less than four pages;
- EC2) Documents that do not mention African American, Latinx/Hispanic, or Native American;
- EC3) Documents from educational institutions outside of the U.S.;
- EC4) Documents that are not undergraduate level.

The process of selecting relevant articles began in 2019 and was updated annually, with the last search taking place in February 2024 with papers from 2023. Figure 2 (based on PRISMA [21]) presents a summary with the sum of the document numbers (conference and journal) from the entire process. The important point is that some search tools changed their systems, but it was possible to execute the search string, with few variations, predicted in 2019 in all academic databases. Using the academic databases engines, the filter documents with IC1, IC2, IC3, the number total of documents was 10,733. The second step was done manually by co-authors reading the title and abstract, 630 documents were selected. In the last step, after reading the papers, 521 relevant documents were selected for this literature review paper; the list of papers is here https://bit.ly/FIE24-Relevant-Papers.

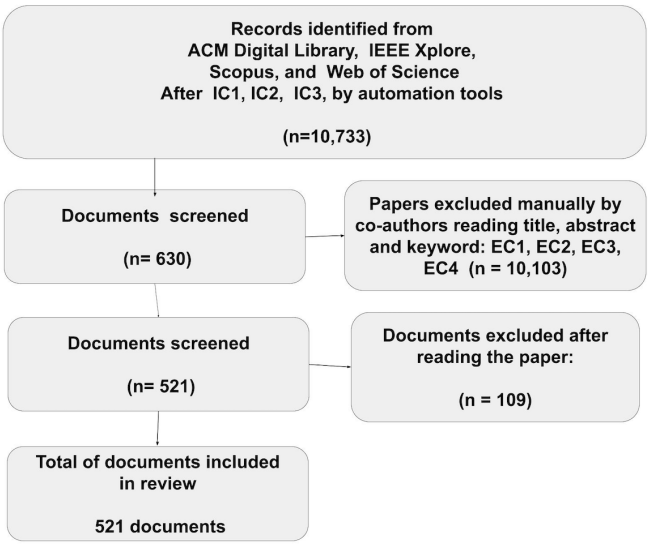

Fig. 2. PRISMA process.

III. Findings

This section presents the answers to the four research questions.

A. RQ1 - What types of publications are there (conference, journal, year and states) about activities focused on including underrepresented minority groups in Computer Science majors in the United States?

Figure 3 presents the 521 papers (conferences and journals) found per year (2009 to 2023). There has been an increasing number of papers published in these 15 years. In the last five years, 329 papers were found, representing more than 63% of all documents in this literature mapping. The average number of papers found per year was around 34.

We found 411 papers published in 45 conferences (Table I). ASEE (American Society for Engineering Education), FIE (Frontiers in Education Conference), and SIGCSE (Special Interest Group on Computer Science Education) accounted for 279 papers, about 53.5% of the total number of papers over the last 15 years.

Figure 3 also presents the distribution of journal articles by year. Table II presents the 53 journals where 110 articles were published. ACM Transactions on Computing Education (14 articles) and Journal of Computing Sciences in Colleges (13 articles) published the highest numbers of articles, 23.6% of articles in journals (27 articles).

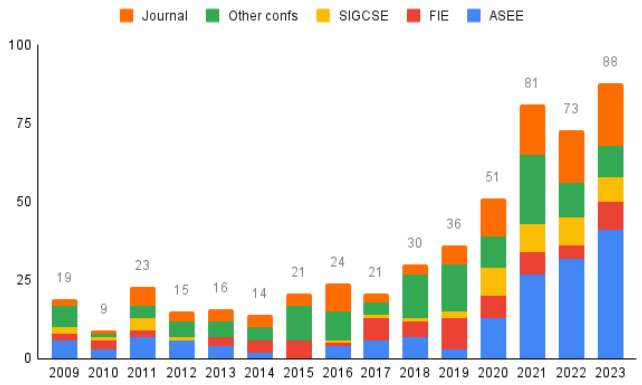

Fig. 3. Papers by Conference.

Figure 4 presents the distribution of papers by state. The states with the highest numbers of publications are California (102), Texas (73), Florida (50), Pennsylvania (33), Virginia (33) and New York (32). At least one paper was found in 42 states and the US territory of Puerto Rico. Table III presents the number of papers per state.

B. RQ2 - Which colleges/universities have published on this topic?

We found authors from 260 different colleges/universities. Table IV presents the universities with ten or more papers. The universities with the most publications are Florida International University (27), the University of Texas at El Paso (25), and Purdue University (22). Table V presents the universities with scores of 4 or higher in the U.S. News ranking in 2024 for

TABLE I
CONFERENCES WITH 2 OR MORE PAPERS

Name	Papers
ASEE - American Society for Engineering Education	161
FIE - Frontiers in Education Conference	70
SIGCSE - Special Interest Group on Computer Science Education	48
RESPECT - Research on Equity and Sustained Participation in Engineering, Computing, and Technology	20
ITiCSE - Innovation and Technology in Computer Science Education	19
ICER - Conference on International Computing Education Research	9
ISEC - Integrated STEM Education Conference	7
XSEDE - Conference on Diversity, Big Data, and Science at Scale	5
CoNECD - Collaborative Network for Engineering and Computing Diversity	4
ACM-SE - ACM SouthEast Conference	3
CSCI - Computational Science and Computational Intelligence	3
SIGMIS-CPR - Annual conference on Computers and people research	3
SIGITE - Annual SIG Conference on Information Technology Education	3
TAPIA - Richard Tapia Celebration of Diversity in Computing	3
AMCIS - Americas Conference on Information Systems	2
CSEET - Software Engineering Education & Training	2
EDUCON - IEEE Global Engineering Education Conference	2
Koli Calling - International Conference on Computing Education Research	2

TABLE II
JOURNALS WITH 2 OR MORE ARTICLES

Name	Papers
ACM Transactions on Computing Education	14
Journal of Computing Sciences in Colleges	13
Computer Science Education	6
Research in Higher Education	4
IEEE Transactions on Education	4
Journal of Diversity in Higher Education	4
International Journal of Engineering Education	3
Computers & Education	3
Journal of Women and Minorities in Science and Engineering	3
ACM Inroads	2
Communications of the ACM	2
Computing in Science & Engineering	2
IEEE Transactions on Learning Technologies	2
Journal of Engineering Education	2
Journal of Information Systems Education	2
Journal for Multicultural Education	2
Journal of Negro Education	2
Journal of Hispanic Higher Education	2

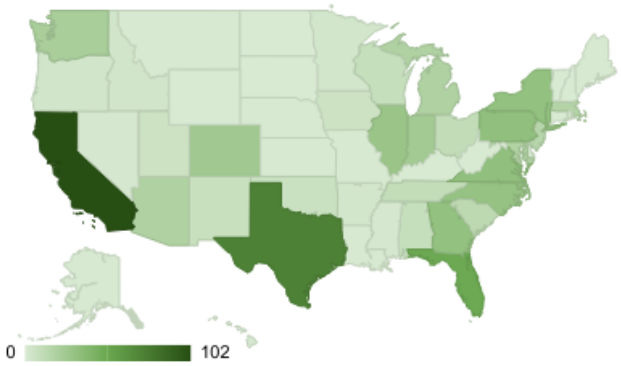

Fig. 4. Papers by State.

TABLE III
STATES WITH 10 OR MORE PAPERS.

State	Papers
California	102
Texas	73
Florida	50
Pennsylvania	33
Virginia	33
New York	32
Georgia	32
North Carolina	31
Illinois	29
Colorado	26
Indiana	25
Washington	22
Arizona	19
Michigan	19
Maryland	18
New Jersey	16
Massachusetts	17
South Carolina	13
Ohio	11
Tennessee	10

best Computer Science Schools [1]. The University of Illinois at Urbana Champaign, the Georgia Institute of Technology, the University of Washington, the University of California at San Diego, the University of California at Los Angeles and Purdue University are in Table IV and Table V.

C. RQ3 - What are the document types (report, perceptions, educational model, educational data mining, and others)?

To answer RQ3, the authors classified the papers into four categories:

- Educational data mining (EDM): which provides techniques for analyzing educational data by URM undergraduate students such as data mining, data visualization, and regression applied to the prediction of academic performance in CS majors;
- Educational Model: which describes educational activities such as differentiated teaching methods in CS and new strategies to retain URM undergraduate students in CS;
- Report: when the paper presents data about URM undergraduate students in CS majors;
- Perception: when the paper presents the perceptions of URM undergraduate students in CS majors;
- Program: when the paper presents a program to include URM undergraduate students in CS majors;

Figure 5 presents the document types by years. We found 48 papers for EDM, 163 papers for Educational Model, Report 37, Perception 105, and Program 198. The figure shows an increase in papers in practically all categories, with programs, educational model, and perceptions having the most articles in all the years analyzed.

The Report type presents the demographic of undergraduate students in minority groups in computer science. The Program type has papers on many NSF projects, including undergraduate research, mentoring programs, workshops for welcome, leadership programs, and others. Educational data mining (EDM) presents analysts with educational data, and may include predictions, detection of the risk of dropout, and other aspects.

Figure 6 presents the word cloud created with the paper titles classified into the Perception category. The CS identity, the importance of the sense of belonging, the experiences of the other undergraduate students, and the community were the subjects most frequently described in those papers. The word black was associated with women in the following five papers: The double bind of race and gender: A look into the experiences of women of color in engineering (d159), Intersectionality in the narratives of black women in computing through the education and workforce pipeline (d211), The intersectional experiences of black women in computing (d347), Examining Psychological and Social Factors That Impact the Experiences and Representation of Black Women in Computer Science (A Case Study)(d443), and Nevertheless, They Persisted: Factors that Promote Persistence for Women and Racially/Ethnically Minoritized Students in Undergraduate Computing (d340).

The educational model was classified into five types: teaching changes (88 papers), curriculum changes (58 papers), support to students (14 papers), learning communities (10 papers), and others (6 papers). Figure 7 presents the distribution of these types per year. The teaching changes (green) and curriculum changes (red) have papers in all years. Most of the papers are about the teaching changes, which will be described bellow.

Table VI presents the main changes in teaching used to include more URM groups in CS majors. These are: Active Learning, Instructional Technologies, Lecture Content, Problem Solving, Learning Environment, Teamwork and Collaboration, Tools, and Others. Regarding lecture content, papers d232 and d362 applied black music to educational practices. Lectures that addressed Ethics in AI algorithms were d258, d006, d95, d313, and d399. For Instructional Technologies,

[1]https://www.usnews.com/best-graduate-schools/top-science-schools/computer-science-rankings

TABLE IV
UNIVERSITIES WITH 10 OR MORE PAPERS

University	No.	Papers
Florida International University	27	d048, d081, d127, d158, d177, d185, d260, d261, d263, d265, d271-d272, d281, d297-d298, d301, d329, d341, d351, d403, d420, d454, d466-d468, d475, d508
University of Texas at El Paso	25	d019, d024, d045, d058, d113, d120, d123, d136, d146, d158, d171, d208, d212, d275-d276, d363, d368, d370, d435-d437, d459, d479, d505, d511
Purdue University	22	d082, d097, d142, d174, d177, d185, d187, d206, d209, d225, d261, d285, d289, d291, d301, d341-d343, d385, d388, d454, d472
Texas A&M University	17	d093, d098, d126, d185, d234, d269, d318, d319, d331, d344, d428, d429, d491-d493, d516, d517
Arizona State University	15	d003, d015, d021, d025, d069, d105, d110, d135, d150, d176, d242, d277, d407, d463, d494
University of Colorado at Boulder	14	d001, d018, d024, d049, d076, d101, d120, d146, d158, d192, d227, d328, d422, d447
University of Michigan	14	d133, d185, d189, d200, d217, d262, d315, d328, d339, d382, d415, d456, d463, d481
Virginia Tech	14	d047, d089, d148, d209, d248, d292, d314, d345, d350, d401, d464, d487, d496, d514
University of California Los Angeles	14	d002, d088, d199, d258, d294, d304, d357, d367, d369, d374, d379, d444, d488, d514
University of California San Diego	13	d068, d078, d204, d333, d334, d337, d339, d349, d352, d359, d396, d398, d450
University of North Carolina Charlotte	13	d009, d031, d106, d111, d140, d141, d169, d226, d322, d361, d362, d380, d397
Howard University	13	d040, d055, d083, d087, d219, d226, d362, d363, d371, d377, d381, d405, d445
Clemson University	12	d170, d177, d036, d084, d193, d228, d229, d306, d341, d445, d462, d489
University of Washington	12	d018, d074, d143, d185, d332, d376, d474, d477, d511, d512, d513, d521
Georgia Institute of Technology	10	d079, d080, d115, d181, d185, d243, d250, d273, d305, d387
University of Illinois at Urbana Champaign	10	d369, d171, d214, d383, d433, d432, d159, d474, d503, d504

TABLE V
UNIVERSITIES WITH SCORES 4 OR HIGHER IN BEST COMPUTER SCIENCE SCHOOLS IN U.S. NEWS RANKINGS.

University	No.	Score	Papers
Massachusetts Institute of Technology	0	4.9	We did not find papers
Carnegie Mellon University	3	4.9	d092, d154, d315
Stanford University	6	4.9	d107, d266, d290, d300, d386, d498
University of California at Berkeley	7	4.9	d088, d172, d303, d314, d315, d399, d498
University of Illinois at Urbana Champaign	10	4.7	d369, d171, d214, d383, d433, d432, d159, d474, d503, d504
Cornell University	3	4.6	d247, d300, d441
University of Texas at Austin	9	4.5	d051, d076, d123, d130, d208, d309, d336, d436, d481
Georgia Institute of Technology	10	4.5	d079, d080, d115, d181, d185, d243, d250, d273, d305, d387
University of Washington	12	4.5	d018, d074, d143, d185, d332, d376, d474, d477, d511, d512, d513, d521
Princeton University	1	4.4	d246
University of Michigan	14	4.4	d133, d185, d189, d200, d217, d262, d315, d328, d339, d382, d415, d456, d463, d481
Columbia University	2	4.3	d102, d184
California Institute of Technology	0	4.2	We did not find papers
University of Wisconsin at Madison	3	4.2	d052, d180, d182
University of California at San Diego	13	4.2	d068, d078, d204, d333, d334, d337, d339, d349, d352, d359, d396, d398, d450
University of California at Los Angeles	14	4.2	d002, d088, d199, d258, d294, d304, d357, d367, d369, d374, d379, d444, d488, d514
Harvard University	1	4.1	d188
University of Maryland at College Park	4	4.1	d022, d135, d405, d511
University of Pennsylvania	5	4	d041, d102, d147, d385, d509
Purdue University	22	4	d082, d097, d142, d174, d177, d185, d187, d206, d209, d225, d261, d285, d289, d291, d301, d341-d343, d385, d388, d454, d472

Alice (d020), Robotics (d020, d039, d154), Games (d198, d216, d381) were used. Among Tools, we found on-line tutors (d116,399,d129,d121), feedback systems (d049,d332), and Assessments (d389, d162,d163,d049).

IV. DISCUSSION

In the last 15 years (2009-2023), the number of publications with the theme of inclusion for URM undergraduate students has grown, and especially so in the last 5 years. These publications are in 45 conferences and 53 journals. The data in this paper shows how the ASSEE, SIGCSE, FIE conferences are important for disseminating affirmative actions to include URM students in CS majors. The contribution of the RESPECT (Research in Equity and Sustained Participation in Engineering, Computing, and Technology) conference, which had its first edition in 2015, is evident from the publication of more than 7.7% of the total number of papers published in the last 5 years.

A highlight for journals is the ACM Transaction on Education, which has published the most articles on the topic and has increased its publication rate in the last five years.

The American states with the highest number of publications are California, Texas, and Florida. These three states have about half of the U.S. Latino population [22], while Texas and Florida have the largest Black population in the

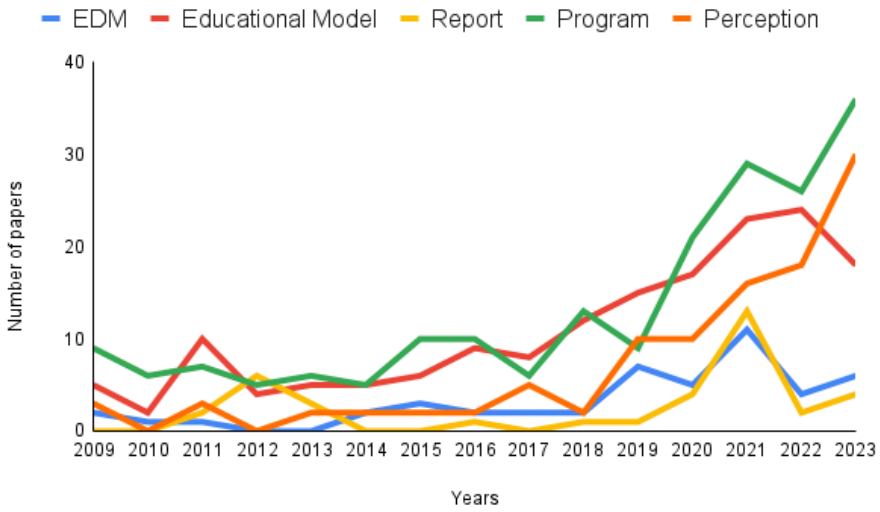

Fig. 5. Document Type.

TABLE VI
TEACHING CHANGES

Topic	Quant.	Papers
Active Learning	10	d048, d106, d111, d235, d256, d257, d311, d362, d482, d490
Instructional Technologies	19	d020, d033, d039, d062, d103, d128, d154, d198, d216, d315, d316, d320, d348, d381, d385, d426, d432, d433, d497
Lecture Content	19	d104, d181, d183, d232, d234, d251, d258, d296, d313, d315, d350, d362, d384, d394, d399, d482, d490, d496, d519
Problem Solving	28	d031, d048, d055, d065, d066, d089, d101, d102, d138, d152, d153, d166, d182, d191, d222, d231, d248, d253, d254, d255, d257, d259, d295, d362, d427, d457, d482, d490
Learning environment	6	d044, d214, d250, d311, d416, d453
Teamwork and Collaboration	25	d031, d048, d055, d065, d066, d089, d101, d102, d152, d166, d182, d222, d231, d247, d248, d254, d255, d256, d295, d296, d427, d457, d482, d490, d498
Tools	10	d049, d116, d121, d162, d163, d315, d332, d389, d392, d393
Others	6	d240, d245, d390, d448, d491, d500

Fig. 6. Perception.

U.S. [23]. Those were the states with the most publications in this literature mapping.

The two universities with the highest number of publications, Florida International University and the University of Texas at El Paso, are Hispanic-Serving Institutions (HSI). An institution is recognized as an HSI if at least 25% of its undergraduate full-time student body identifies as Hispanic. The institution with the third highest number of publications (20 articles) found in this literature review was Purdue University, which is not an HSI but has done strong work in diversity [24].

Five of the 20 universities with scores of 4 or higher in Best Computer Science Schools in the U.S. News Rankings were classified among the universities with the highest number of publications on the topic, the University of Illinois at Urbana Champaign, the Georgia Institute of Technology, the University of Washington, the University of California at San Diego, the University of California at Los Angeles and Purdue University. We did not find papers published by authors in Massachusetts Institute of Technology or California Institute of Technology.

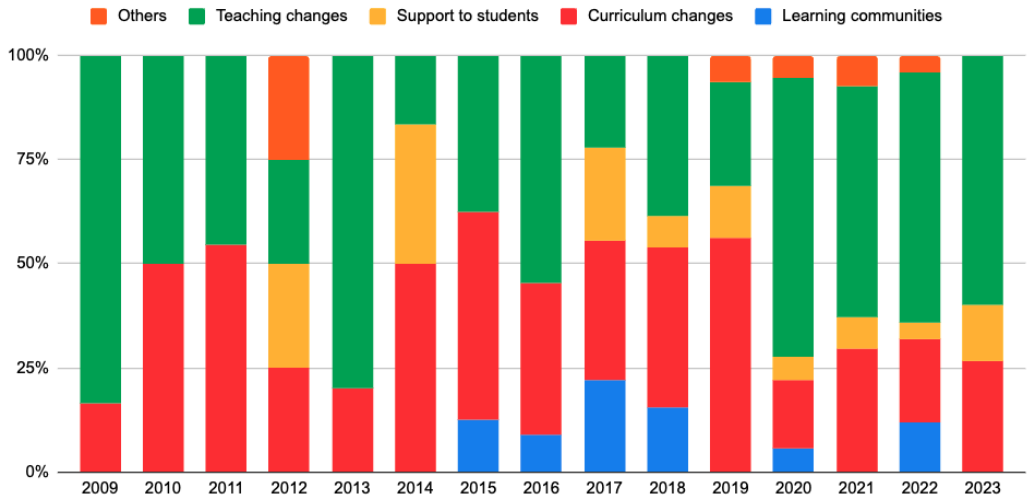

Fig. 7. Educational Model

The papers found were classified into different types, with educational models, programs, and perceptions being the most prevalent. Most commonly occurring in the educational model category were teaching changes including collaborative learning, problem-based learning, learning communities, and others.

V. Limitations

This paper is a study of publications from conferences and journals. Any initiatives not disseminated through the publication of academic papers are excluded. Furthermore, a common threat in systematic mapping is inadequate coverage of papers on the topic area. To ensure the inclusion of relevant documents, the definition of the search string with keyword analysis used Vosviewer, meetings, and defined the pre-process analysis.

VI. Conclusion

This paper presents a quantitative study of papers about underrepresented minority (African American, Hispanic/Latinx, and Native American) undergraduate students in Computer Science majors in the United States.

The authors identified 521 relevant papers published from 2009 to 2023. The papers were written by authors from 260 higher educational colleges/universities at 45 conferences and in 53 journals. California and Texas were the states with the highest number of publications. Teaching changes was the most commonly reported topic.

Many universities have developed projects aimed at including minority groups in computing courses. Identifying these universities can assist researchers from similar regions, sizes, and types (public or private) in creating their own inclusion projects. Additionally, this research aims to determine whether well-ranked universities have initiatives for including undergraduate students from minority groups.

For future works, the authors will investigate the impact of the affirmative actions the papers present, and examine positive factors for the inclusion of more URM undergraduate students in CS majors.

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