International Journal of Current Trends in Engineering & Research (IJCTER)
e-ISSN 2455–1392 Volume 2 Issue 2, February 2016 pp. 24 - 31
Scientific Journal Impact Factor : 3.468
http://www.ijcter.com

# Computing Education for K-12 Schools in India

**Bhukya Madhu[1], Rajaram Jatothu[2]**

[1]*Department of Computer Science Engineering, JNTU Hyderabad, India*
[2]*Department of Computer Science Engineering, JNTU Hyderabad Research Scholar, India*

**Abstract—** the present paper, the focus of Computer Science Education (CSE) in primary and secondary schools (shortly K-12) has reached a significant turning point. This study reviews the published papers on the field of K-12 Computer Education in order to summarize the findings, guide future studies and give reflections for the major achievements in the area of CSE in K-12 schools. 47 peer-reviewed articles were collected from a systematic literature search and analyzed, based on a categorization of their main elements. Programming tools, educational context, and instructional methods are the main examined categories of this research. Results of this survey show the direction of CSE in schools research during the last years and summarized the benefits as well as the challenges. In particular, we analyzed the selected papers from the perspective of the various instructional methods aiming at introducing and enhancing learning, using several programming tools and educational context in K-12 CSE. Despite the challenges, the findings suggest that implementing computing lessons in K-12 education could be an enjoyable and effective learning experience. In addition, we suggest ways to facilitate deep learning and deal with various implications of the formal and informal education. Encouraging students to create their own projects or solve problems should be a significant part of the learning process.

**Keywords—** Computer Science Education, computer programming, programming pedagogy, educational context, programming tools, Instructions, K-12 Education

## I. INTRODUCTION

The introduction of technology has revolutionized education and that has given birth to new modes of education. One of the new modes that have changed the way education is imparted is the K-12 education. K-12 education is an educational concept that is widely gaining in popularity in countries like United States of America, Canada and India as well, among other countries. This kind of educational system is different from the conventional method of teaching and involves a more teacher-student communication than the conventional version. Read on and find out more on K-12 education system and its presence in India. The K-12 education is the term used to denote the education imparted in the primary and secondary phases of a school life, including K or kindergarten to 12 which stands for the 12th standard. This particular system covers the education from kindergarten till the 12th grade. The concept is slowly gaining its importance in India with the government introducing new educational schemes like free compulsory primary education throughout the country. K-12 education system includes a lot of teacher-student interaction with the teacher encouraging lot of question-answer sessions, assignments that would promote interesting learning habits in students. Individual attention is another key factor of the education system. This method of teaching is beneficial and let the students develop learning and understanding capabilities on their own. The teacher plays the ideal guiding star in their success. One of the main points that sets this system apart from its conventional counterpart is the fact that, other than the typical classroom activity of students preparing and submitting assignments, they are also encouraged to add values to their assignments in the form of personal views and ideas. They are also motivated to take part in various discussion clubs and forums to exchange ideas and views. The introduction and rising popularity of the K-12 education system in India itself stands witness to the reformed education system in the country. The mode of teaching as well as the content and resources have changed to a great extent to facilitate more involvement of students. Schools nowadays, invests good amount to create the best infrastructures for their students. Students, on their part, must grab the best of these facilities and available resources offered for the optimum learning. This kind of platform is what the K-12 education system promotes and this is what more and more schools in India are adapting to if creating individuals is what the main aim of the present day education system is all about, then the K-12 is all that should be adopted. More teacher-student harmony and more self-reliable, independent individual who can create difference, not just for the school, but for the society as a whole is what this new educational revolution has to offer.

## II. METHODOLOGY

### *A. Overview*

For the context of this study, we have considered a peer reviewed search in the following international online bibliographic databases: AACE Digital Library, Academic Search Premier, Association for Computing Machinery Digital Library, and EBSCO Education Source included ERIC. Our searching key terms were "learning" and "programming" and "young students". We also included the terms "games", "constructionism" or "do it yourself". The examined period was five years, from January 2009 to December 2013. This process was conducted independently by two experts, a CS educ. researcher and a research librarian and resulted in 1514 articles.

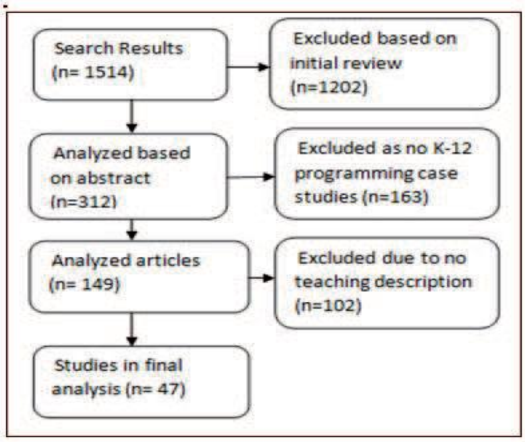



**Figure 1: Methodology**

A first step of this effort was to exclude papers describing case studies in process, posters, conference reports, and not related papers. Then, based on the papers' abstracts, we excluded articles irrelevant to programming curricula and tools and not K-12 students learning. Afterwards, we were based on the whole content of each article in order to explore the various technology based pedagogical approaches used in K-12 CSE. We found several papers which were concerning programming tools (e.g. Alice [69], Scratch [52], Kodu [63]), virtual worlds programming tools (e.g. SLurtles [4]), and programming video games (e.g. Game Gidget [11], the achineers [12] or the Smart Lady Game [22]). Additionally, many papers were referring not only to the typical school environment but also to camps, after school or summer programs, like the Beowulf Boot camp [1], the Digital Divas [10], and many others. In this step, we decided to exclude papers without a detailed description of the teaching design process or with informal learning as it would be impossible for us to validate the teaching process integration. Finally, we examined the content of the remaining papers with focus on the research methodology, and the quality of the results evaluation. Finally, we decided to include some surveys which didn't describe an instructional method, due to the lack of papers referring to tangible programming interfaces. We finally chose a total number of forty seven papers for the needs of this review. A list of the selected papers can be found at the end of the reference section of the paper. We believe that the included articles can provide us with a useful guideline of teaching approaches aiming at teaching computing in K-12 education

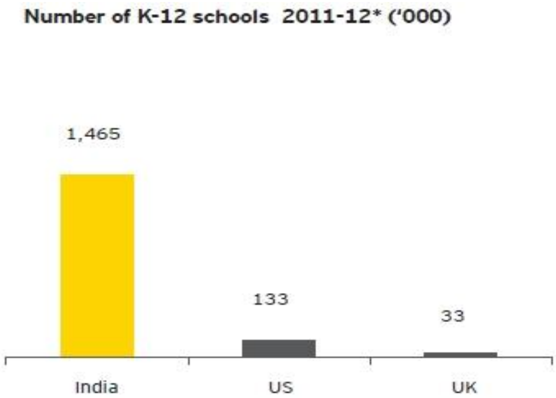
***B. Types of Papers collected***

An analysis of these 47 studies context revealed our classification scheme, which is described by the following categories:

**Programming tools**

Many tools have been introduced in order to teach computing to young students in K-12 CSE. Most of them are modern, offering a usable interface with many opportunities, and aiming at making computing more attractive. In categorizing the various programming tools, we have based on the following assumptions. A text programming language may include a text or a graphical user interface. The programming process though means typing text lines. When a programming language includes primarily visual expressions, then it is a visual (graphical) one. This graphical interface is more usable to the novice learners. The visual programming process needs the ability to map various on-screen symbolic representations like icons and other graphical objects to their results [2]. Finally, in the tangible interfaces, learners have the opportunity to manipulate directly tangible objects which actually form the generated code [56].

The various programming languages which have been used for educational purposes could be




generally categorized into textual, visual, and tangible according to the "look" of their code. In our research, we distinguished approaches using a text based (n=12), a visual (n=29), or a tangible programming language (n=3). Finally, in 3 papers more than one programming tool were employed.

**Educational context**

Most of these research papers present: various computing concepts (e.g. control flow and variables), skills (e.g. procedural thinking), and practices (e.g. debugging) in a project based methodology. Our focus though, was not on the programming curriculum itself, but mainly on the educational context, which has been used in order to motivate and enhance students learning. Under this perspective, we distinguished the following categories: game design and development (n=17), programmable physical - tangible tools (n=18), modeling and computation (n=3), and music generation (n=1). There were also (n=8) papers describing more than one or not exactly

**defined contexts.**

A summary of the benefits and disadvantages of the most popular approaches in computing education indicates different options and challenges. Although we need to highlight that it is not easy to decide the most suitable approach, as long as each case has different characteristics (e.g. students' backgrounds, experience, and expectations).

**Instructional methods**

Teaching programming needs further abilities than knowing how to program. Several computing concepts must be represented and formulated in order to make comprehension effective. In addition, many difficulties have to be overcome [19]. In our review work, we have focused on the instructional methods used with the various programming tools and educational contexts, with the aim to motivate and enhance students' learning. Under this perspective, categorization is not an easy issue. In our approach, we distinguished various methods while teaching such as text, visual, tangible, and game programming, modeling, and programmable objects platforms. We do not specify methods for the K-12 CSE, but we only provide with useful guidelines aiming at helping educators' decisions and posing leading guiding questions for further research.

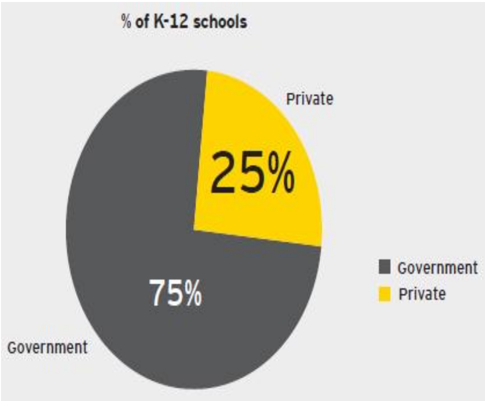
## III. RESULTS AND DISCUSSION

Many researchers indicate the importance of a creative, technology-enhanced learning in order to broaden CSE and to provide young students with skills like computational thinking. India has the highest number of schools and the highest number of students enrolled in the K-12 system as compared to the US or the UK.

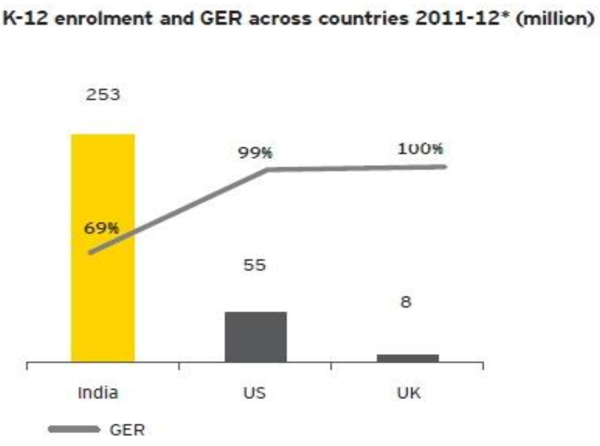
The current K-12 school system in India is one of the largest in the world with more than 1.4 million schools with 250+ million students enrolled, reveals EY-FICCI report on the education sector in India.
Schools have grown at a CAGR of 2.5% from 1.2 million in 2005 to 1.4 million in 2011 and enrolment has grown at a CAGR of 2.2% to reach 253 million students in 2011.

**Highlights of the K-12 education sector in India**

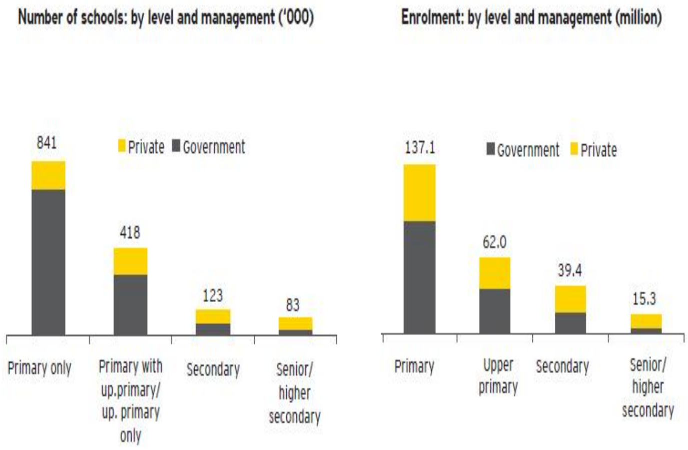
1. The K-12 systems in India can be segmented by ownership, level of education and board of affiliation.
2. 25% of all K-12 schools in India are private schools, accounting for 40% share in student enrolment.




3. 54% of all 1.46 million K-12 schools in India, are managed by the Central Government/ state governments and 21% are managed by local bodies/municipal corporations. Private schools account for 25% of the total number of K-12 schools in India.
4. The number of schools and student enrolment decline drastically with increase in level.






- Although the share of all secondary/higher secondary schools is only 14%, the share of enrolment is much higher at 22%.
- Overall, utilization in private schools is higher, more so at the primary and secondary level as compared to the government schools.
- Primary Schools constitute 57% of all schools; upper primary schools form 10%; primary with upper primary form 19% while secondary/ higher secondary form 14%.
- 137 million students enrolled in primary level constitute 54% of all students enrolled in K-12 schools.

5. 96% of K-12 schools in India are affiliated to state boards, 1% to CBSE, 0.1% TO CISCE and 2% are unrecognized.
6. In addition to the Indian boards, a large number of schools across India tie up with International Boards.

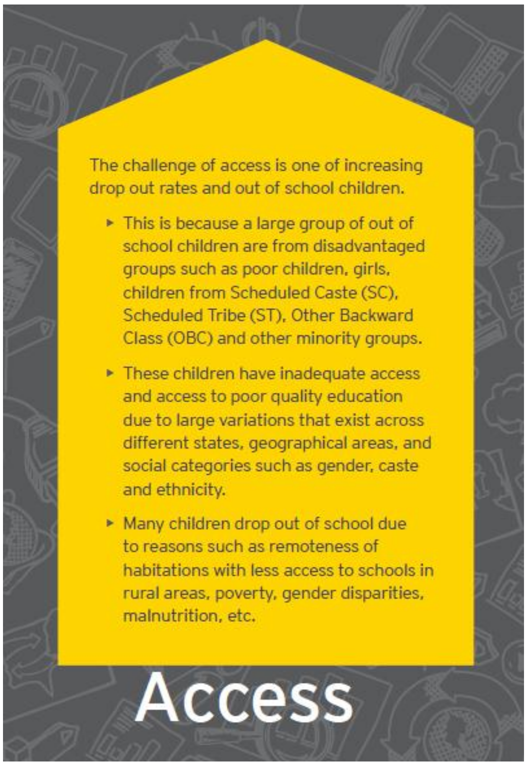
**Contribution by the private sector K-12 education in India**

1. India has ~100 million students enrolled as compared to the US or the UK that have 5.1million and 504,000 private school students respectively.
2. Evidence of increasing enrolment in private schools in rural India- from 18.7% in 2006 to 25.6% in 2011 and declining enrolment in government schools.
3. The share of private schools enrolment at the primary level is 30.6% and 37.1% in upper primary levels. Secondary education accounts for 54.4% in the junior secondary level and 60.3% in the senior/higher secondary level.
4. 69 million students study in 247,843 private schools at the elementary level making the average number of students per school at 280.
5. India has more than 339,000 private K-12 schools, growing in the last five years at a CAGR of 4%.
6. Around 130,000 additional private schools will be required by 2022 given the current trends
7. Private schools enrolment in the top 20 states account for nearly 55% share of enrolment at the secondary/higher secondary level.

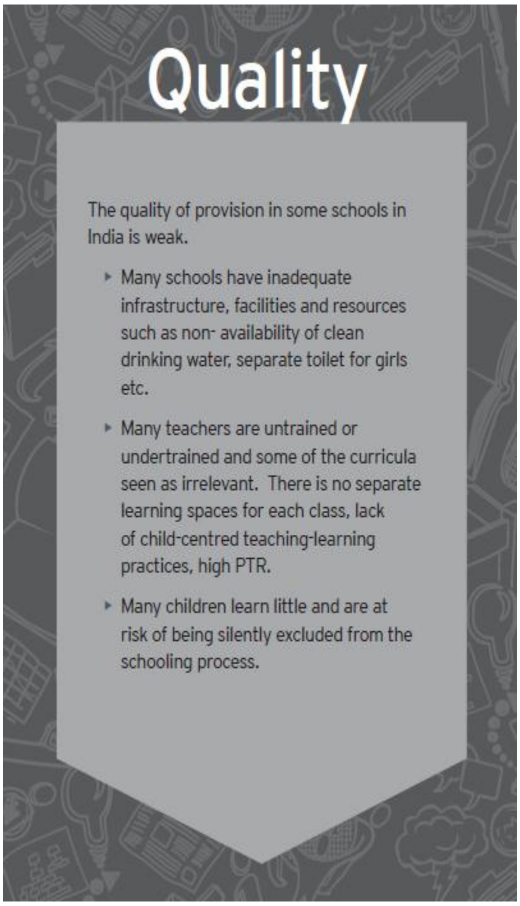
**Role of private sector on K-12 education in India**

1. Low enrolment across senior classes remain a key challenge in the K-12 education system
2. Dropout rate of girls at primary and secondary level has increased in comparison to that of boys
3. Population of out-of-school children is significantly high in certain social groups and rural areas
4. Low learning levels pose serious questions over the quality of education; school children opting for paid supplemental help




5. Lack of adequate infrastructure, poor facilities and shortage of quality resources impact the quality of education
6. High teacher vacancies, lack of training and high pupil-teacher ratio affect the quality of delivery



**Key challenges faced by the private sector in K-12 education in India**

- Inflexible and complex regulatory norms.
- Inadequate compensation by the government for 25% EWS.
- Schools facing closure due to RTE norms and scale.
- High capital cost.
- Inability to access equity funding.
- High upfront cost in the initial years.
- Suggestions and recommendations.
- Reduce input based norms – move to outcomes based system.
- Allow schools on short term leases/ rental model.
- Allow hub and spoke model.
- Pooling of government and private resources.
- Reduce land area requirements/provide flexibility in land ownership.
- Allow companies to set up schools across states.
- Allow private schools flexibility on salaries in initial years.
- Single window clearance.
- Flexible norms for eligibility of private player.
- Regulation of fees.
- Admissions.
- Clarity on new school set-up.

## IV. CONCLUSIONS

Our goal for this chapter was to provide practical solutions for a complex problem, and while we cannot claim that any of our lists are exhaustive, they do provide a powerful set of suggestions that, if put into practice, will significantly improve computer science engineering in high schools. The reality is that we are at somewhat of a crossroads. We know that the world continues to change and that many of the changes we face are related to the burgeoning possibilities and consequences of our growing dependence upon and interrelation with computing technology. Maintaining our ability to meet the challenges of the present and future require us to think very carefully about the kind of knowledge our students need to grow and to succeed. Supporting and improving high school computer science engineering and ensuring that the opportunities it provides are open to all students requires a multilevel commitment. It is a commitment we must make if our schools are to continue to provide relevant education and our society is to continue to solve problems on the cutting edge of innovation.

## REFERENCES

[1] C. Girvan, B. Tangney, & T. Savage, “SLurtles: Supporting constructionist learning in< i> Second Life</i>,” Computers & Education, Vol. 61, pp. 115-132, 2013.
[2] S. Grover, and R. Pea, "Computational thinking in K–12. A review of the state of the field," Educational Researcher, Vol. 42.1, pp. 38-43, 2013
[3] M. Guzdial, "Software□realized scaffolding to facilitate programming for science learning," Interactive Learning Environments, Vol. 4.1, 001-044, 1994.

[4] C. E. Hmelo-Silver, R. G. Duncan, and C. A. Chinn, "Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006)," Educational Psychologist, Vol. 42.2,pp. 99-107, 2007.
[5] D. W. Johnson, R. T. Johnson, &K. A. Smith, " Cooperative learning: Increasingcollege faculty instructional productivity", ASHE-ERIC Higher Education Rep. No. 4, 1991.
[6] C. Kelleher, R. Pausch, "Lowering the barriers to programming: A taxonomy of programming environments and languages for novice programmers," *ACM Computing Surveys (CSUR), Vol.* 37.2 pp. 83-137, 2005.
[7] C. Lang, A. Craig, J. Fisher, & H. Forgasz, "Creating digital divas: scaffolding perception change through secondary school and university alliances," In Proceedings of the fifteenth annual conference on Innovation and technology in computer science education, pp. 38-42, ACM, June2010.
[8] M. J. Lee, A. J. Ko, & I. Kwan, "In-game assessments increase novice programmers' engagement and level completion speed," In Proceedings of the ninth annual international ACM conference on International computing education research, pp. 153-160, ACM, August 2013.
[9] H. Lode, G. E. Franchi, & N. G. Frederiksen, "Machineers: playfully introducing programming to children," In CHI'13 Extended Abstracts on Human Factors in Computing Systems, pp. 2639-2642, ACM, April 2013).
[10] S. R. Brandt, C. Dekate, P. LeBlanc, & T. Sterling, "Beowulf bootcamp: teaching local high schools about HPC," In Proceedings of the 2010 TeraGrid Conference, p. 4, ACM, August 2010.
[11] M. M. Burnett, "Visual programming," Wiley Encyclopedia of Electrical and Electronics Engineering, 1999.
[12] Y. Eshet, " Digital literacy: A conceptualframework for survival skills in the digital era," *Journal of Educational Multimedia and Hypermedia*, Vol. *13*(1), pp. 93-106, 2004.
[13] B. A. Myers, "Taxonomies of visual programming and program visualization,"Journal of Visual Languages & Computing, Vol. 1.1 pp. 97-123, 1990.
[14] S. Papert,and I. Harel, "Situating constructionism," *Constructionism*36: 1-11. 1991.
[15] S. Papert, and M. Resnick, "Technological Fluency and the Representationof Knowledge," Proposal to the National Science Foundation, MIT MediaLaboratory, 1995.
[16] M. Resnick, "Rethinking learning in the digital age," 2002. [17] A. Robins, J. Rountree, and N. Rountree, "Learning and teaching programming: A review and discussion,"*Computer Science Education* Vol. 13.2, pp.137-172, 2003.
[17] J. M. Roschelle, R. D. Pea,C.M. Hoadley, D.N. Gordin, & B. M. Means, "Changing how and what children learn in school with computer-based technologies", . The future of children, pp. 76-101, 2000.
[18] M. Saeli, J. Perrenet, W. M. Jochems, &B. Zwaneveld, "Teaching programming in secondary school: a pedagogical content knowledge perspective," Informatics in Education-An International Journal, vol 10_1, pp. 73-88, 2011.
[19] H. Webb, "Computer applications for the classroom: A review," Journal of Computing Sciences in Colleges, Vol. 27(3), pp. 65-72, 2012.
[20] J. M. Wing, "Computational thinking," Communications *of the ACM*, Vol. *49*(3), pp. 33-35, 2006.
[21] A. Zeid, G. Al-Mirza, & L. Al-Meshwah, "SLG: an online educational simulation game to teach programming concepts," In Proceedings of the Second Kuwait Conference on e-Services and e-Systems, p. 15, ACM, April 2011.