Computer Assisted Education:

A Survey of the Algorithms & Consequences behind Automated Teaching & Learning

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INTRODUCTION

- **Computer-assisted Education** (CAE) is the use of electronic devices and computers to teach and learn.
- Automated problem generation & automated feedback can provide a personalized learning experience for students because they can analyze a user's progress using specifically defined models input by instructors, creating a **synthesis of human instruction & computational instruction.**

OBJECTIVE

- The main objective is to provide a **survey** of different algorithms used to achieve **personalized** education, particularly **automated feedback generation & automated problem generation**. We also consider trade-offs & analyze how **emotional & social development** for students are affected by depriving them of interaction with teachers & peers.
- **Can a more digitized scholarly experience detract from the development of our youth, or can an intellectually, emotionally, & socially balanced citizen still be produced if human teachers are not part of the equation?**

CONCLUSION

- We acknowledge we have **not reached a point** where machines can be the sole providers of education, as they lack the ability to guide students across obstacles that can only be detected by humans.
- Nonetheless, being able to create **meaningful feedback & problems** brings us closer to having computers resemble human instructors to allow them to focus their energy on truly irreplaceable tasks while using automated systems to enhance the class.
- Computers do not have to perfectly match the intelligence of humans to be powerful. Creating a **synthesis of human instruction & computer-based instruction** will enrich the educational experience for **all** who participate.

AUTOMATED FEEDBACK GENERATION

- Meaningful feedback is important for students to be able to monitor & track their performance, "while making sure they're on the right path towards their goals" [1]
- The traditional approach is for a teacher or grader to read through a student's solution & figure out what they're thinking.
- How can we automate this process?

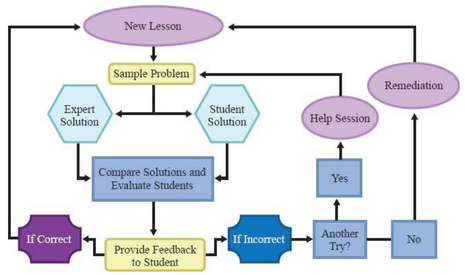

Fig. 1 . This flowchart indicates a general path for computer assisted instruction, aimed to determine whether a student understands the lesson or needs remediation [13]

Microsoft's Counter Example Guided Inducted Synthesis

CEGIS takes an error model defined by an instructor, feeds it to the system, & learns how to offer feedback & possible corrections. The system "automatically derives minimal corrections to student's incorrect solutions, providing feedback about what they did wrong" [2]. Comparing this modeled solution to the input answer by the student reduces the amount of feedback comments it must generate.

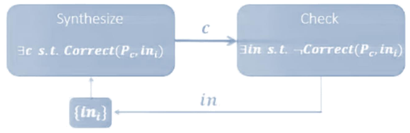

Fig. 2 CEGIS Algorithm: Finds feedback comments that work for set of answers. Randomly synthesizes possible answers. Checks if those comments work for them. Eliminates comments that do not work, creating a finite bank of possible corrections [3]

BENEFITS	DISADVANTAGES
Computer-generated feedback is **instantaneous**, allowing a problem solver to immediately reflect on incorrect responses	Online programs can lead to **poorly self-regulated** access to information & expecting students to follow lessons with minimal intervention from an instructor.
Human error & **bias** when grading are **decreased,** producing a scientifically accurate & objective saving time, money, & resources simultaneously	Many students need more than artificially generated responses to their questions from instruction that **cannot provide further discourse** in a human manner
The Association for Supervision & Curriculum Development found that of 453 teachers who flipped their classroom to include mainly online learning, 67% saw **an increase in student test scores** [4]	Teachers who foster positive relationships with their students create learning environments that meet all needs. "Teaching & learning is **too complex, too human** a craft to be taken over by robots" [5]

AUTOMATED PROBLEM GENERATION

A Trace-based Framework for Analyzing & Synthesizing Educational Progressions

This tool generates problems for a given procedural concept by using "off-the-shelf test input generation tools" to illustrate the underlying procedure but written as code.

This method characterizes a problem using its "trace characteristics" which can be used for problem generation like filling holes in each progression, comparing different progressions from different textbooks, & generating individualized progressions to integrate interactive instruction. [6]

Concept	Trace characteristic	Sample input
Single-digit addition	L	3 + 2
Multiple-digit addition without carry	LL^+	1234 + 8765
Single carry	$L^*(LC)L^*$	1234 + 8757
Two single carries	$L^*(LC)L^+(LC)L^*$	1234 + 8857
Double carry	$L^*(LCLC)L^*$	1234 + 8667
Triple carry	$L^*(LCLCLC)L^*$	1234 + 8767
Extra digit in input and new digit in output	L^*CLDCE	9234 + 900

Fig. 3 This table proposes a sample progression based on student progress, using an assessment software to practice algebra, a procedural topic. [6]

Procedural vs Conceptual

This works for procedural topics like math & other sciences, & even conceptual topics like natural language learning.

For both, the algorithm generalizes a problem type into a template that takes in parameters to replace number values, operators, or vocabulary words that are within the same family.

El estudiante tiene que _____ para llegar a la escuela.

a) comer
b) hablar
c) bailar
d) caminar

Fig. 4 A sample vocabulary question that takes words from a database that have been used in similar sentence structures, a conceptual topic.

BENEFITS	DISADVANTAGES
Intelligent computer-based system adjusts itself automatically to the best method for an individual learner, letting them **work at their own pace**.	**Discussion, deliberation, & collaboration** with peers give show student's progress & understanding of the material. Software **cannot** read cognition & psychological language.
Problem generation can reduce the issue of students falling behind or advancing too quickly as the software **prioritizes progress** over staying on schedule.	Relying on an algorithm to create a roadmap for an entire lesson plan can leave **gaps that may stunt a student's ability** to master everything before moving on to new levels.
Researchers are getting impressive results by using software that generates problems & lessons **in conjunction** with classrooms.	Achieving **all-around** student engagement with these personalized courses is difficult, especially for those **struggling** with the course material.

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