

Project Proposal

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Abstract—Intelligent Tutoring Systems (ITSs) and Individualized Education Plans (IEPs) have existed for decades in education. Researchers, through meta-analyses, have demonstrated the efficacy of ITS(s), irrespective of field of study (technical and non-technical subjects) in K-12 education (Ma et al, 2014). Modern ITS are capable of evaluating and identifying a student’s emotional state and meta-cognitive skills, such as self-monitoring, self-explanation, etc (Conati, 2009). Since the 1970s, IEPs are, by law, implemented for students which are covered by IDEA (Individuals with Disabilities Education Act). An IEP is constructed annually by educators, administrators, and parents of special education students to define specific academic and functional goals per student. Building on existing research and education practice, this project will deliver a resource for any individual constructing a curriculum for a K-12 student, looking to implement ITS(s) within a field of study. The resource will be a web-based interface (website) for parents/tutors/teachers and students to provide: (1) a background on IEP history and usage; (2) guidelines for planning a student’s curriculum with ITS(s) implemented; (3) a repository and search tool for commercially available ITS.

1 HEADER

1.1 Title

Guidelines for Individualized Academic Curriculum and ITS Implementation for K-12 Students: a Resource Guide (GIACII-K12).

1.2 Team

Thomas B Pizzone

2 INTRODUCTION

2.1 Background & Value

2.1.1 ITS

For decades, researchers, through meta-analyses, have demonstrated the efficacy of ITS(s), irrespective of field of study (technical and non-technical subjects) in K-12 education. “Students who used ITS learned significantly more than students who used other modes of instruction except small-group and individual human tutoring” (Ma et al, 2014). Based on the history of research efforts, the positive impact measured for ITS versus other learning styles suggests that students excel when given the opportunity to have more control over their learning. For example, (Ritter et al, 2014)’s ITS software product presents students with questions and hints only when necessary, like a personal tutor overseeing their work, allowing students to continue at their own pace.

Capabilities of ITS increase as a function of developments in the fields of Cognitive Science, and Artificial Intelligence and Machine Learning. (Katz et al, 2010) & (Reeve et al, 2006) have demonstrated students’ psychological needs, such as the need for perceived support and feeling of autonomy in their education. The methods of assessing student needs provided in a traditional classroom are possible through an ITS. Modern ITS are designed to identify emotional state and meta-cognitive skills, such as self-monitoring, self-explanation, learning from example, and effective help seeking (Conati, 2009).

2.1.2 IEP

For students who have been evaluated and determined to have a disability and in need of special education, their needs fall under federal law, IDEA (Individuals with Disabilities Education Act, formerly the Education for All Handicapped Children Act) (Yell et al, 2020). “The goal of the IDEA is to individualize a student’s education plan. This plan must be appropriate to the student’s unique needs.” Furthermore, “the goals must meet the child’s needs, relative to their disability, to “make progress in the general curriculum”, as well as meet the education needs relative to their disability (IDEA, 2006).

In 2000, a new concept for IEP meetings was developed, the Facilitated Individualized Education Program (FIEP).

“The federally funded Technical Assistance Center for Appropriate Dispute Resolution in Special Education (CADRE) first introduced and recognized the FIEP meeting process as a beneficial and emerging ADR practice that offers IEP teams the opportunity to process decisions and reach agreements about the IEP, they and their parents utilize FIEP (facilitated individual education programs).” (Mueller et al, 2019)

Parents and students found an FIEP (facilitated individual education programs) approach to be empowering and rewarding (Mueller et al, 2019).

Though an IEP is only required by law for students under IDEA, the inclusion of parents, private educators or tutors and students in the development of an education plan, as with FIEP, offer the stakeholders an opportunity to focus on each students’ individual educational needs. For this project, the guidelines for developing an academic curriculum will be built on the history of IEP (and FIEP) implementation, and will foster the inclusion and deployment of ITS when applicable.

2.2 Perceived Audience/User

Though much of the research for this project has been spent on the current practices of IEPs, the envisioned users for the resource will not be parents, guardians, or instructors of students which are captured under the IDEA. The existing IEP definition, captured in Table 1 below, is the definitive resource for those individuals.

A proper needfinding exercise will be needed to accurately identify who would benefit most from this project. However, for the scope of this project, the perceived audience or users will include parents and educational instructors (if different) of K-12 students in the United States. When determined appropriate by their guardian, students should be part of the curriculum development discussion.

3 RELATED WORK

3.1 Six Sigma Method & Leadership in Energy and Environmental Design

Guidelines or best practices are tools in the private and public sector to reduce variability and standardize an industry's approach to a common goal. The goal of improved quality for the 1980's was birthed from the estimated loss of US businesses in the 1970s. From (Montgomery et al, 2008), one "US automobile company estimated its operating losses at nearly \$1 million per hour in 1980." The Six Sigma programme was initiated by Bill Smith, an engineer, at Motorola in 1986. From the adoption of Six Sigma, Motorola is estimated to have "reduced defects on semiconductor devices by 94% between 1987 and 1997", and the practice has been adopted across the manufacturing, finance and healthcare industries. Put simply, Six Sigma is a problem-solving approach built on 5 specific steps: Define, Measure, Analyze, Improve, and Control. LSS (Lean Six Sigma), the next evolution of the programme, was defined by (Snee, 2010) as "a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results."

The U.S. Green Building Council, a non-profit, was founded in 1993 to facilitate a "green" building system, now known as Leadership in Energy and Environmental Design (LEED). From this effort, LEED certification established a standard rating system for assessing a building's design and construction with respect to its environmental sustainability or impact. In 2009, USGBC released LEED v2009. This version

"introduced weightings for credits based on the Environmental Protection Agency's TRACI (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts) and weightings developed by the National Institute of Standards. This advancement made LEED much more rigorous and indicated which credits were most important. For the first time there was objective scientific intentions behind the assigned credit values" (USGBC, 2022).

3.2 ITS Development

Irrespective of area of study, (Ma et al, 2014) found that students who were provided an ITS in their education structure outperformed students in other

schooling models, except individual human tutoring, to a statistically significant level. (Kulik et al, 2016)'s meta-analysis demonstrated ITS can be successfully employed for reading comprehension as well, and they found ITS to have a statistically neutral or positive effect when compared with a tutor. As summarized by (Kochmar et al, 2021), "ITS have been actively used to teach technical subjects", including algorithms, logic, mathematics, and natural sciences. Furthermore, systematic reviews of ITS as a method for reading comprehension in K-12 has shown a large effect size versus traditional instruction (0.86) (Xu et al, 2019).

From (Ma et al, 2014), the first recognized instance of an ITS, though the term was not used by the author, was Jaime Carbonell's program called SCHOLAR in 1970.

"The main purpose of the research reported here is to show that a new and more powerful type of computer-assisted instruction (CAI), based on extensive application of artificial-intelligence (AI) techniques, is feasible, and to demonstrate some of its major capabilities.

...SCHOLAR can also generate questions and evaluate the student's answers, deciding when these are correct, wrong, or only approximately or partially correct, and then take some conditional actions.

...The research leading into the development of SCHOLAR can also be considered as an investigation on an aspect of man-computer interaction, namely, the possibility of having mixed-initiative man-computer discourse. This mode of interaction is of interest for areas of application other than CAI."
(Carbonell, 1970)

Significant progress has been made since Carbonell's early effort. Research for the efficacy of ITS as an educational tool has not been limited to the analysis of test scores. ITS developers have built ITS software and proposed ITS methodologies which address learning styles, personality types, emotion, metacognitive change. (Conati, 2009) determined that a human or artificial intelligent tutors must possess 3 knowledge bases: "(i) knowledge about the target instructional domain, (ii) knowledge about the student, and (iii)

knowledge about the relevant pedagogical strategies". Conati defines a fourth knowledge field "communication knowledge", meaning, how to present the information. With domain and communication knowledge, an ITS can present information and problem statements to students according to the students' abilities and preferences.

The systems are not only able to "tutor", but through tutoring, they can enforce positive education habits, which will serve students beyond a single course. The use of an ITS to improve a students' meta-cognition was found to be a lasting benefit. (Flavell 1976) defines meta-cognition as "one's knowledge concerning one's own cognitive processes and products or anything related to them". Within a students' meta-cognitive ability are their skills of self-monitoring, self-explanation, learning from example, and effective help seeking. (Roll et al, 2011) researched how an ITS can improve students' help-seeking abilities. Their research encompassed two studies which were designed to evaluate students' behaviors with regard to help-seeking as a function of "The Help Tutor", an ITA (intelligent tutor agent). This ITA was integrated into a commercial ITS for geometry, "Geometry Cognitive Tutor". In the first study, the researchers observed an improvement in the students' desire to seek help, and in the second study, they found that this behavior was transferable to study areas in which the ITA was not implemented. The work of (Roll et al, 2006) / (Roll et al, 2011) expanded on the meta-cognitive impact of an ITS.

(Soudani et al, 2013) investigated ITS which adapted to the different learning styles of students and to the emotional state of students. They proposed the ITS "PATS" (Personalized Affective Tutoring System) that tailor the users' learning environment as a function of the users' learning style and emotions. The results of their research show a statistically significant improvement in the users' average correct answers on tests and in the users' satisfaction with the program when comparing the PATS system with user modeling versus without user modeling.

3.2 IEP Development

Since 1975, the educational needs of students, who have been evaluated and determined to have a disability and in need of special education, fall under federal law, IDEA (Individuals with Disabilities Education Act, formerly the Education for All Handicapped Children Act). These students with disabilities

are required to receive “a program of special education and related services that conferred a FAPE (Free Appropriate Public Education)” (Yell et al, 2020). To comply with this requirement, educators, administrators, and parents of special education students develop the FAPE per student at the IEP (Individualized Education Plan) meeting. The students themselves may be included, but that is only required under law when the student reaches the age of majority.

The IEP is constructed annually with specific goals for the student, and as such, the special education teachers must inform parents, periodically, of the child’s progress in the IEP. Specifically, the goals are both academic and functional. The goals must meet the child’s needs, relative to their disability, to “make progress in the general curriculum”, as well as meet the education needs relative to their disability (IDEA, 2006).

The goal of the IDEA is to individualize a student’s education plan. This plan must be appropriate to the student’s unique needs. Table 1 below includes the definition, under the law for the IEP.

Table 1— 34 CFR § 300.320 Definition of individualized education program.

Requirement	Description
(a) General	As used in this part, the term individualized education program or IEP means a written statement for each child with a disability that is developed, reviewed, and revised in a meeting in accordance with §§ 300.320 through 300.324, and that must include -
	1) A statement of the child's present levels of academic achievement and functional performance, including -
	a) How the child's disability affects the child's involvement and progress in the general education curriculum (i.e., the same curriculum as for nondisabled children); or
	b) For preschool children, as appropriate, how the disability affects the child's participation in appropriate activities;
	2)
	a) A statement of measurable annual goals, including academic and functional goals designed to -
	i) Meet the child's needs that result from the child's disability to enable the child to be involved in and make progress in the general education curriculum; and
	ii) Meet each of the child's other educational needs that result from the child's disability;
	b) For children with disabilities who take alternate assessments aligned to alternate academic achievement standards, a description of benchmarks or short-term objectives;
	3) A description of -
	a) How the child's progress toward meeting the annual goals described in paragraph (2) of this section will be measured; and
	b) When periodic reports on the progress the child is making toward meeting the annual goals (such as through the use of quarterly or other periodic reports, concurrent with the issuance of report cards) will be provided;
	4) A statement of the special education and related services and supplementary aids and services, based on peer-reviewed research to the extent practicable, to be provided to the child, or on behalf of the child, and a statement of the program modifications or supports for school personnel that will be provided to enable the child -
	a) To advance appropriately toward attaining the annual goals;
	b) To be involved in and make progress in the general education curriculum in accordance with paragraph (a)(1) of this section, and to participate in extracurricular and other nonacademic activities; and
	c) To be educated and participate with other children with disabilities and nondisabled children in the activities described in this section;
	5) An explanation of the extent, if any, to which the child will not participate with nondisabled children in the regular class and in the activities described in paragraph (a)(4) of this section;
	6)
	a) A statement of any individual appropriate accommodations that are necessary to measure the academic achievement and functional performance of the child on State and districtwide assessments consistent with section 612(a)(16) of the Act; and
	b) If the IEP Team determines that the child must take an alternate assessment instead of a particular regular State or districtwide assessment of student achievement, a statement of why -
	i) The child cannot participate in the regular assessment; and
	ii) The particular alternate assessment selected is appropriate for the child; and
	7) The projected date for the beginning of the services and modifications described in paragraph (a)(4) of this section, and the anticipated frequency, location, and duration of those services and modifications.
(b) Transition services	Beginning not later than the first IEP to be in effect when the child turns 16, or younger if determined appropriate by the IEP Team, and updated annually, thereafter, the IEP must include -
	(1) Appropriate measurable postsecondary goals based upon age appropriate transition assessments related to training, education, employment, and, where appropriate, independent living skills; and
	(2) The transition services (including courses of study) needed to assist the child in reaching those goals.
(c) Transfer of rights at age of majority	Beginning not later than one year before the child reaches the age of majority under State law, the IEP must include a statement that the child has been informed of the child's rights under Part B of the Act, if any, that will transfer to the child on reaching the age of majority under § 300.520.
(d) Construction	Nothing in this section shall be construed to require -
	(1) That additional information be included in a child's IEP beyond what is explicitly required in section 614 of the Act; or
	(2) The IEP Team to include information under one component of a child's IEP that is already contained under another component of the child's IEP.
(Authority: 20 U.S.C. 1414(d)(1)(A) and (d)(6))	
[71 FR 46753, Aug. 14, 2006, as amended at 72 FR 61307, Oct. 30, 2007]	

4 PROPOSED WORK

4.1 Overview

Teachers, parents, private tutors and students have a difficult task in defining coursework to suit all students. There are the pitfalls of subconscious biases, financial limitations, and innumerable texts and lesson plans from which to choose. As opposed to setting a standard curriculum for K-12 education, my goal is to assist in the development of a student's curriculum. I plan to offer a web-based interface. The interface will act as a resource to provide: (1) a background on IEP history and usage; (2) guidelines for planning a student's curriculum with ITSs implementation; (3) a repository and search tool for commercially available ITS.

4.2 Interface as an Information Resource.

IEPs have been a part of public education since EAHCA, now Individuals with Disabilities Education Act (IDEA), was passed in 1975. While in use for over 40 years, the audience has been focused on parents, students and educators who are stakeholders under IDEA. In order to best present the concept and effect of an individualized plan of education to any interested party, my project will provide: (1) content on IDEA-IEP history, (2) introduce the concept of Facilitated IEP (FIEP), (3) and offer published research on procedural and substantive requirements for IEPs.

4.3 Interface as a Guide for Planning an Individualized Academic Curriculum.

Similarly to the concept of IEP provided in section 2.1 and its definition in Table 1, the purpose of this project is to deliver a set of guidelines to individualize a student's education plan. These guidelines will facilitate an academic curriculum appropriate to the student's unique needs. Additionally, the guidelines will foster instructors (private tutors, parents, teachers) and students to set periodic and measurable goals in both education and personal growth.

4.3.1 Planning for Guideline Construction

The bedrock of the guidelines will be the existing law governing IEP, captured in Table 1 above. However, I plan to benchmark against other resources as well. This includes researching existing education plans offered in homeschool and private school formats will be a task in my development of the guidelines. For

differences in my delivered product and the IEP guidelines under the law, I will offer detailed reasoning and data when possible.

4.2 Interface as a Repository and Search Resource for K-12 ITS

In section 2.3, the efficacy of ITS for instruction in K-12 education was demonstrated. ITS are applicable across subject fields as well, not simply the more technical education domains. My project will host a detailed breakdown of the commercially available ITS that may be implemented within a student's curriculum as a primary or supplementary education tool.

4.2.1 Not all Intelligent Tutoring Systems are Created Equal

For perspective ITS customers, necessary details include: cost, subject or domain, academic level (i.e. K-12), reviews, advertised education-based behavioral trait improvement, published research for the tutor's efficacy, and evaluation of personality & learning type. Not all tutors will have had research projects to demonstrate their efficacy in comparison to traditional classrooms. Nor will all tutors be adaptive to the user based on personality evaluation and mapping to learning style. Regardless of the latest technological developments for ITS in AI and Cognitive Science, I perceive subject/domain, academic level offered, and cost as the three most significant weighted factors in choosing an ITS.

4.2.2 Database, API and Scraping / Crawling

A task item within the first two week of this project will be to brainstorm and construct a database schema which will be used to host all the details related to commercial ITS and insert the data as it is available. At the time of writing the proposal, my approach for compiling available ITS will be to review my research log for all papers referencing ITS and searching for them online. Should I find a systematic approach to this, find an existing API for searching ITS, or develop a scraping tool to gather relevant ITS data, I will include those details in the final paper and link to any code in the webpage upon its release.

4.4 Content Deployment

As described in section 4.1, the project end-state is a web-based interface (a website) which will host all the content described above. However, the specific platform (Heroku, OpenShift, Back4app, Google App Engine, etc.) is yet to be decided, and one of the items in my task list, section 8. The task list section offers

a greater breakdown of the interface design cycle, including brainstorming, prototype construction and evaluation, platform selection, and UI design and deployment.

For the most part, the content will be collected, analyzed, evaluated and organized within weeks 6 and 7. The website will be built and populated in weeks 8, 9 and 10. The final weeks of the project will be focused on design evaluation and testing for failure, as well as completing the paper and presentation.

5 DELIVERABLES

5.1 Milestone 1

For the second project milestone, the video will encompass the web interface prototypes and current content. For the two prototypes, wireframe and card, the narration of the video will cover the current iterations' proposed functionality, and the details of their evaluation methodology and evaluation results will be included. For the current content, the outline of all the IEP and ITS information that will be gathered by the due date of milestone 1 will be included in the video demonstration.

5.2 Milestone 2

For the second project milestone, the video will encompass two aspects of the project. First, the current status of interface with walkthrough to demonstrate functionality. Second, the video will showcase the current features of ITS repository.

5.3 Final Project Deliverable

The final project package will include:

1. Final Project Paper, including all research sources/citations.
2. Final Project Presentation, including slides and demonstration of website.
3. Link to website.
4. Database scripts and dump file of database content.
5. Prototypes and their evaluation data.

8 TASK LIST

Table 2— CS-6460 Project Task List of Thomas Pizzone

Week #	Task #	Task Description	Estimated Time (Hours)	Member Responsible
5	1	Outline history to IDEA & IEP	2	Thomas
5	2	Outline history of Lean Six Sigma Methodology	1	Thomas
5	3	Outline history of "LEED" Methodology	1	Thomas
6	4	Benchmarking of homeschool and private education planning guides	5	Thomas
6	5	Compose rough draft-1 of guidelines for individualized curriculum and ITS implementation	2	Thomas
6	6	Brainstorm and Build out SQLite-based DB for ITS repository.	2	Thomas
6	7	Research & Compile initial repository of commercially available ITS for K-12 education. Push ITS characteristics to DB.	5	Thomas
6	8	Web Resource UI Brainstorming Session (1)	0.5	Thomas
6	9	Web Resource UI Brainstorming Session (2)	0.5	Thomas
6	10	Wireframe Prototype for UI	1.5	Thomas
6	11	Card Prototype for UI	2	Thomas
7	12	Qualitative Analysis of UI Prototype: Compose Survey for friends & family to evaluate prototype	1	Thomas
7	13	Qualitative Analysis of UI Prototype: Recruit friends & family to complete survey for prototype evaluation	0.5	Thomas
7	14	Predictive Analysis of UI Prototype: Compose Cognitive Walkthrough parameters for me to test the card prototype	1	Thomas
7	15	Predictive Analysis of UI Prototype: Complete Cognitive Walkthrough of the card prototype	1	Thomas
7	16	Complete Qualitative Analysis of the Wireframe Prototype	2	Thomas
7	17	Complete Predictive Evaluation of the Card Prototype	2	Thomas
7	18	Research and determine open-source web-platform to host UI	2	Thomas

7	19	Prepare video for Milestone 1. Include: - Prototypes and their evaluation. - Outline and substance of content for web pages gathered up to this point.	2	Thomas
		INTERMEDIATE MILESTONE 1 DUE		
8	20	Review rough draft-1 and compose rough draft-2 of guidelines for individualized curriculum and ITS implementation	3	Thomas
8	21	Interface: Initial layout including homepage	5	Thomas
8	22	Interface: replicate latest iteration of wireframe prototype as pages of website	8	Thomas
8	23	Interface: replicate latest iteration of card prototype (functionality, including navigation / dropdowns, etc.)	5	Thomas
8	24	Interface: Complete population of IEP content	5	Thomas
9	25	Interface: Populate backend of platform with ITS database	5	Thomas
9	26	Interface: Complete first draft of ITS catalog/search page	5	Thomas
9	27	Prepare video for Milestone 2. Include: - Current status of interface with walkthrough to demonstrate functionality. - Showcase features of ITS repository.	2	Thomas
		INTERMEDIATE MILESTONE 2 DUE		
10	28	Finalize guidelines for individualized curriculum and ITS implementation	5	Thomas
10	29	Interface: Finalize IEP content	2	Thomas
10	30	Interface: Finalize Guideline content	2	Thomas
10	31	Interface: Complete functionality of ITS repository (filtering, search fields, etc)	5	Thomas
11	32	Interface: Finalize ITS included within repository	2	Thomas
11	33	Interface: Finalize webpage as project deliverable	5	Thomas
11	34	Final Project Documentation & Paper	10	Thomas
11	35	Final Project Presentation & Video	5	Thomas
		FINAL PROJECT DUE		

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