Development of a Collaborative Intelligent Individual Education Program System using a Prototyping Approach

Nor Shahida Mohamad Yusop
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Malaysia
nor_shahida@uitm.edu.my

Marshima Mohd Rosli
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Malaysia | Institute of Pathology, Laboratory and Forensic Medicine (I-PPerForM), Universiti Teknologi MARA, Malaysia
marshima@uitm.edu.my (corresponding author)

Nur Farahin Farid
National Autism Resource Centre (NARC), College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Malaysia
nurfarahinnfarid@gmail.com

Nur Aqila Syafika Mohd Nazri
National Autism Resource Centre (NARC), College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Malaysia
aqilasyafika.nazri@gmail.com

Nursuriati Jamil
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Malaysia
liza_jamil@uitm.edu.my

Muhammad Izzad Ramli
College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Malaysia
izzadramli@uitm.edu.my

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ABSTRACT

The current paper describes the development of an online Collaborative Intelligent Individual Education Platform (CIIP) that is specifically designed for children with ASD based on experts' assessments and progress reports. The online platform facilitates the progress of children with special needs as it is established on their individual needs and can be accessible anywhere. The CIIP system was developed following a prototyping model approach that comprised initial requirements, design, prototyping, customer evaluation, review and refinement, development, testing, and maintenance. Two cycles of prototyping evaluation were conducted to confirm the final requirements. The results of the prototype evaluation by the stakeholders indicated that 29 changes were required before progressing to the final development of CIIP. System testing was carried out with expert testers to ensure the CIIP functions and the satisfaction of the expected requirements. The results showed that 22% of the test cases failed due to difficulties with complicated interconnections in several modules. Despite these challenges, CIIP was able to meet the requirement specifications and perform as expected.

Keywords-system development; prototyping; individual education program

I. INTRODUCTION

An Individual Education Program (IEP) is one of the most important components in offering special education services to children with disabilities [1]. An IEP outlines a personalized educational plan that aims to provide every child with special needs access to a relevant and high-quality education tailored to their needs [2]. An IEP is designed to document at least eight elements: the student's current level of achievement, the annual goals, a series of short-term objectives that will help accomplish the annual goals, a special education program to be provided, related special services to be provided, student participation in regular classes, projected start and end dates of the education program, as well as objective evaluation criteria and procedures [3]. The development of IEP systems has gained momentum in recent years due to the increasing demand for efficiency, data-driven decision-making, compliance, inclusivity, and stakeholder engagement in special education services [4-7]. These systems offer a centralized platform for teachers, administrators, parents, and other stakeholders to collaborate, monitor progress, and ensure that the IEP is carried out as intended. Additionally, IEP systems enable data-driven decision-making through the provision of detailed student profiles, progress reports, and assessment data. Although several systems are available to facilitate the implementation of IEP [6-8], most of them lack the adaptability to meet the specific needs of local organizations, such as the National Autism Society Of Malaysia (NASOM), which requires tailored interventions for individuals with Autism Spectrum Disorders (ASD). NASOM practices a highly intensive intervention program, known as the STAR (Strategies for Teaching Based on Autism Research), which is an extensive curriculum designed to address the special learning requirements for individuals with ASD. This program covers a wide range of areas, including social skills, academic abilities, behavior management, communication, and everyday life skills. This study presents a web-based Collaborative Intelligent Individualized educational Plan (CIIP) system that integrates intelligence, personalization, and collaboration to customize learning experiences tailored to the specific needs of children with ASD. The CIIP system consists of three main modules: a personalized educational platform, learning modules, and a report and monitoring system.

Selecting the appropriate system development methodology is essential for creating a complex web-based system [9-12]. A prototyping approach was adopted due to the complexity of the CIIP systems as they are composed of many interrelated modules that contain crucial functions and owing to the difficulty of stakeholders in finalizing all the requirements at once. Although the waterfall model remains the most widely used system development approach, there is an increasing amount of interest in innovative techniques such as prototyping. Prototyping has proven to be a useful method for investigating and verifying complicated system functionalities and requirements in the early stages of the system development [13-16]. Before major investments are made in the development efforts, stakeholders can provide feedback by evaluating prototypes that simulate important functionalities of the final system. Prototype models play an important role in helping users clarify requirements and provide helpful guidance when there are many uncertain requirements [17]. Several studies have applied prototyping in various contexts, such as in e-commerce, education, and health applications, to discover design ideas, validate concepts, and collect user feedback before committing to full-scale development [15, 18-20]. Employing the prototyping method in the development of responsive web profiles improves institutional visibility and user experience [18]. The prototyping method allows for the creation of initial website models that can be tested and evaluated before full development, while also helping to identify user needs and obtain valuable feedback for necessary improvements. The active engagement of the relevant stakeholders and securing adequate resources are necessary to ensure the success of the prototyping method in the website implementation [18]. Prototypes expedite system design iterations by enabling direct users' involvement in requirement gathering. The prototyping method facilitates continuous communication among stakeholders to provide feedback for improvement. The collaborative method can certify that the final system aligns directly with user expectations and can simplify system development [19]. The prototyping method employs an iterative process in the design of information systems. In [20], it was stated that prototyping successfully reduces miscommunication and promotes better understanding among stakeholders by providing a tangible representation of the system's functionality. This study also reported that prototypes help potential users better understand the operation flow and the capabilities of the system. In [5], ePlanning was presented, which is an IEP that applies a decision support system to help create IEPs for students with special needs using an ontology-based representation approach and semantic web technology [8]. This system emppployed a tool for modeling ontological and procedural knowledge, facilitating the modeling process. Semantic web technology played a key role in the development of ePlanning, formalizing procedures, student profiles, suggested objectives, and relevant activities and resources [5]. In terms of IEP development methodology, prototyping emphasizes iterative development and user feedback, whereas ontology-based representation focuses on structuring knowledge within a domain. While prototyping enables early user interaction and rapid iteration, ontology-based representation improves data interoperability and semantic understanding. Prototyping is the best method for evaluating design concepts and fine-tuning user needs, whereas ontology-based representation is appropriate for domains that need automated reasoning and structured data. In summary, prototyping offers a flexible approach to iterative development and user engagement, whereas ontology-based representation and semantic web technology provide an organized approach to data representation and inference [19]. This study presents the CIIP development process deploying the prototyping approach, acting as a case study to illustrate the practical application of this approach in the development of specialized educational systems for children with ASD.

II. METHODOLOGY

The prototyping method was applied in the development of CIIP, consisting of 8 phases: Initial Requirements, Design, Prototyping, Customer Evaluation, Review and Refinement, Development, Testing, and Maintenance. The method focuses on building a prototype. Thus, an early incomplete version of the final system was built, tested, and reworked until an acceptable prototype was achieved, as portrayed in Figure 1.

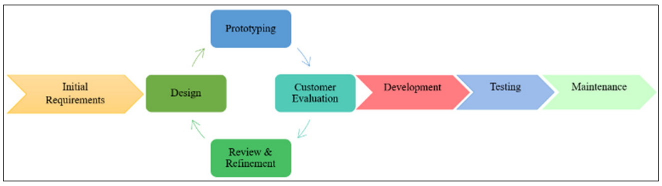

Fig. 1. CIIP development phases.

A. *Initial Requirements*

A focus group discussion was held with 20 stakeholders from NASOM, including teachers, occupational therapists, coordinators, and administrators, to gather requirements. Before the focus group discussion, a preliminary system workflow was created based on the existing business flow outlined in the NASOM process. During the focus group discussion, the proposed workflow was refined through three discussion sessions with the stakeholders, aiming primarily to clarify and confirm the system workflow according to the unique needs and preferences of each user group.

B. *Design, Prototyping, Customer Evaluation, and Review and Refinement*

Figma wireframes were used in the design phase to create a visual representation of the system's interface on the basis of the refined processes in the preliminary system workflow. The interactions between the system functions and stakeholders were outlined deploying use case diagrams. Both wireframes and use case diagrams were integrated into a prototype that outlined the system flow, business processes, rules, and requirement specifications. Before the customer evaluation phase, several focus group meetings were held with stakeholders to clarify unclear requirement specifications at the NASOM center in April 2022. Then, a customer evaluation was conducted with 13 stakeholders on May 14, 2022, to provide feedback on the first prototype, focusing on the overall system flow and lesson module storyboard. After improvement, another customer evaluation was carried out on May 22, 2022, to review the improved prototype and lesson module storyboard with 10 stakeholders. After the two customer evaluations were completed, the prototype was reviewed and refined based on the feedback of the stakeholders. This phase was essential to ensure that the system met the requirements and expectations of the stakeholders before proceeding to the development phase.

C. *Development*

The development phase focused on improving the prototype into a fully functional system. This phase started with code implementation based on the refined prototype. After coding was completed, unit tests and refinements were performed to ascertain that CIIP met the expected requirements. Some issues or bugs were identified, fixed, and tested again to assure that the system was fully functional and ready for the testing phase.

D. *Testing*

Functional testing was carried out to test the functionality of CIIP with four (4) certified external testers from UiTM Shah Alam. The testing involved 10 modules and four CIIP user roles: Teacher, Parent, Coordinator, and Super admin. 263 test cases were created, covering modules 1 to 10 to test the system, and the testers acted as system users. The test cases consisted of case numbers, titles, summaries, scenarios, steps, data, expected results, actual results, status (P/F), and notes. Table I depicts a test case example.

TABLE I. EXAMPLE TEST CASE ON VIEW STAFF PROFILE

Case ID	TC028
Title	Verification of view staff profile function
Summary	To verify the view staff profile function
Scenario	Verify that the user can view the staff profile
Steps	1. Click on the "User Management" menu 2. Click on the "Staff Account" menu 3. Search for staff's name (if necessary) 4. Choose any staff from the list, and click the "View" button
Data	3A. Staff name = Ali bin Abu
Expected result	The user should be able to view the staff profile
Actual result	Same
Status	P

The testers were given one week to complete the test. The testers verified that the behavior of the previous step complies with the criteria and tested the functionality according to the user's needs. In this phase, the testers provided comments on how the system can be improved in terms of usability, efficiency, or user-friendliness. Before the participants started testing, they were asked to understand the system flow to ensure that the data and control flowed seamlessly between different parts or modules of the system and that the user interface behaved as expected and could navigate the system. CIIP was tested using the following criteria [21]:

- Test every integrated component or module within the system.
- Check every input against the intended and anticipated outputs, such as registering new parents and students and creating an IEP plan based on the assessment results.
- •System usability and accessibility for the user.

III. RESULTS AND DISCUSSION

A. *Initial Requirements*

To capture the initial requirements of CIIP, process flows were put into service to brainstorm ideas of what the stakeholders required from the system. Process flows at this stage can uncover interrelated tasks between processes, user interactions with the system, decision points to be made, and business logic. The identified requirements were then mapped to a particular step in the process flow, as exhibited in Figure 2. In this way, the missing and unnecessary requirements can be identified. Figure 3 presents the requirements of CIIP in a use case diagram. There were four (4) user roles, namely Teacher, Parent, Coordinator, and Super admin, and 24 use cases. The 24 use cases were then grouped into ten modules, as listed in Table II.

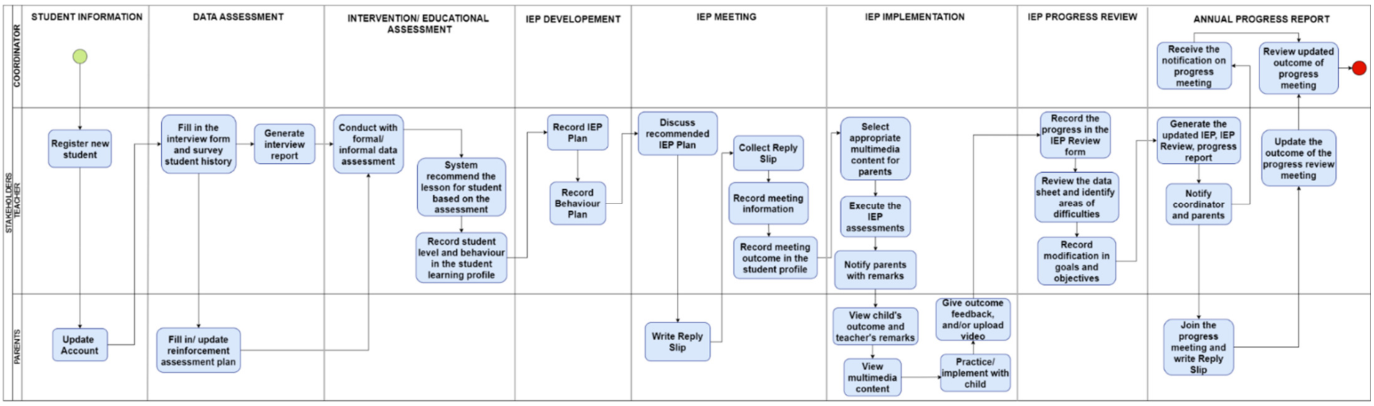

Fig. 2. CIIP process flow.

TABLE II. CIIP MODULES

Module	Related use cases
Student Information	Register new student Update account
Data Assessment	Manage interview and reinforcement form Generate interview and reinforcement report
Intervention/ Educational Assessment	Record informal/formal assessment and student level Verify summary report Generate summary report
IEP Development	Manage IEP plan Verify IEP plan Generate IEP Manage student behavior information Manage ABC chart Manage behavior plan Verify student behavior information Verify ABC chart Verify student behavior plan
IEP Meeting	Manage meeting appointment Confirm attendance Modify IEP Verify modified IEP Review IEP
IEP Implementation	Record student activities Generate multimedia content Manage home assignment Update IEP record View student performance
IEP Progress Review	Manage IEP progress review form Verify IEP progress review Manage IEP progress meeting Confirm meeting attendance Modify IEP Verify modified IEP
Annual Progress Report	Manage annual progress report Verify annual progress report Manage annual progress report meeting Confirm meeting attendance
User Management	Manage staff account Manage leave record Manage student profile
Chatbot	Send enquiry

The detailed requirements of each use case were specified in the use case description and documented in the Software Requirement Specification (SRS). The use case description describes business rules, preconditions, security restrictions (if any), process flow, exception flow, and related documents (if any).

Fig. 3. CIIP use case diagram.

Table III provides an example to describe the Management Interview and Reinforcement Form use case. Normal process flow specifies the interactions between the user(s) and the system for the ideal case in which the user's goal is met. Contrary to the basic process flows, the exceptional flow represents any action that will cause the user to not achieve the desired result. The main benefit of the exception flow is its focus on potential problems that a user might experience. In this example, the common problem for users when filling out digital forms is to leave out the mandatory attributes and fail to select the required options.

TABLE III. USE CASE DESCRIPTION EXAMPLE FOR MANAGE INTERVIEW AND REINFORCEMENT FORM

Title (Scenario)	Manage Interview and Reinforcement Form
Functional description	During the interview session, this use case allows the Teacher and Parents to add, update, and examine interview and reinforcement forms. This procedure should be followed after the Student has been accepted.
Owner	Teacher, Parent
Business rules	Within 14 days of the Student's first day of school, the Interview and Reinforcement Form must be completed.
Pre-condition	NA
Security restrictions	NA
Normal process flow	Parents: Should log into CIIP Click Interview and Reinforcement Form from the Child's Assessment menu. The system will display a list of their children. They should select the respective child, and the system will automatically produce the necessary information, such as the Student's name and ID. They should fill in the Interview and Reinforcement Form before meeting with the Teacher. They should check the Data Declaration box. After completing all required information, they click the Submit button. Teacher: The Teacher should log in to CIIP. Choose Student Assessment > Interview and Reinforcement Form. The Teacher can choose to create a list of Students or search for a Student's ID along with the Student's name. The system will display the necessary information, such as the Student's name and ID. The Date of School field must be updated by the Teacher. During the interview session with Parent, the Teacher can update the Interview and Reinforcement Form. Click the Save button to save any changes. If Parents tick the Data Declaration box, the Teacher can generate the report for the interview and reinforcement form.
Exception flow	6A. Parents do not tick the Data Declaration box: The Submit button will be disabled. The system will alert Parents to tick the Data Declaration box. 10A. If ID/name entered does not exist: The system will alert the Teacher that the ID number/ name does not exist. 12A. If Teacher has not entered Date of School: The Teacher will not be able to input any further information until the required field has been filled.
Related document	Interview and Reinforcement Form

B. *Design, Prototyping, Customer Evaluation, and Review and Refinement*

The ten-module prototype was developed in two phases.

1) *Prototype 1*

In the first prototype, four modules, Student Information, Data Assessment, Intervention/Educational Assessment, and Individualized Education Plan Development, were developed. In total, 145 mock-up frames were designed employing Figma, containing user interface elements, such as buttons, menus, and placeholders, as disclosed in Figures 4 and 5. The first version of the CIIP prototype was demonstrated to NASOM on May 14, 2022. From the mock-up design demonstration, feedback from stakeholders was provided, and nine changes were made to the four modules, as listed in Table IV. Using the visual representation, stakeholders got a better understanding of how the functionalities would work and could identify if there were any design errors. As it can be seen, many of the changes occured due to incomplete user functionality requirements. For example, amendments and revisions to the existing requirements were made in the modules Student Information, Data Assessment, IEP Implementation, and Annual Progress Report.

TABLE IV. FEEDBACK FROM PROTOTYPE 1 - 4 MODULES

Modules	Evaluation feedback	Revised requirements
1 - Student Information	Exclude the Student Admission Module from the CIIP system due to the existing system used by NASOM	Change from Student Admission Module to Student Information module
	Add and keep track of registration history in the Student Profile	Add a column for the Teacher in the registration history of the student in Student Profile
2 - Data Assessment	Interview and Reinforcement Form should be filled in by Parents via the CIIP system	Amend on Teacher roles, only allow for viewing the form
3 – Educational Assessment until 8 – Annual Progress report	Allow only the Teacher to view and update records	Remove the Delete function from Teacher
4 – IEP Development	Change system flow in Intervention/Assessment Module	Behavior Information Form, Behavior Plan, and ABC Chart should be done after IEP development and during IEP Implementation
	Add Students' performance reports using color coordinates (green, yellow, and red) during the early assessment	Show the summary of Students' performance using color coordinates in the result of the early STAR assessment
	No need to show weakness in IEP	Remove the weakness column
	Change the use of the word Month to Period	Amend the word
	Show all three IEP Review Dates (in month) and one report date in IEP	Add one column for the Teacher to fill in the Progress Report Date.

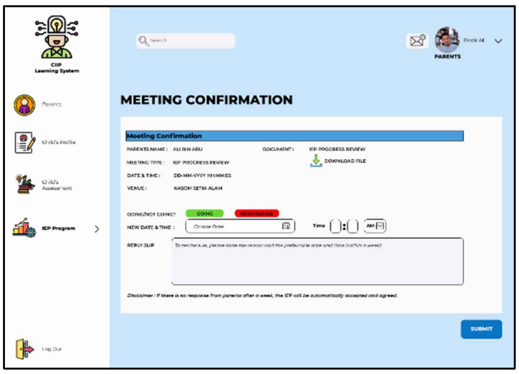

Fig. 4. Parents confirm their attendance at the IEP meeting.

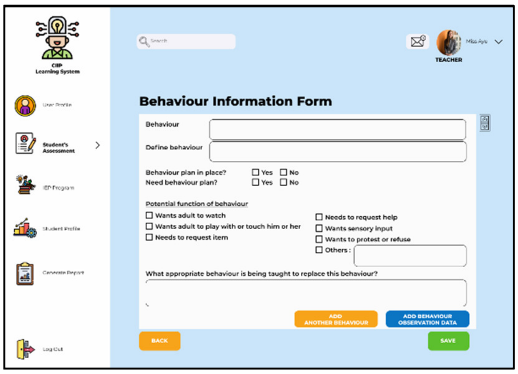

Fig. 5. The Teacher fills in the Behavior Information Form.

In designing multimedia content for CIIP, 11 learning modules were devised utilizing mock-up storyboards and infographics as shown in Table V. Figure 6 displays an example of multimedia content storyboards. Table VI presents the three changes required for each learning module based on user feedback. Iterative improvements were made, refining the layout design of the system flow and the learning modules.

TABLE V. LEARNING CONTENT MODULES

Modules	Content type
Arrival	Animation
Departure	Animation
Transition between activities	Infographic and video
Handwashing	Infographic
Snacks	Animation
Restroom use	Infographic
Going on a walk	Animation
Circle	Animation and video
Centers/Choice	Animation and video
Work with parent	Animation and video
Simple Art Activity	Animation and video

TABLE VI. CHANGES IN LEARNING CONTENT STORYBOARD

No	Evaluation feedback	Changes Made
1	Objectives are not specific	Update objective
2	Tips stated are not detail	Update tips
3	The content delivery method is not suitable for each lesson	Update content delivery method

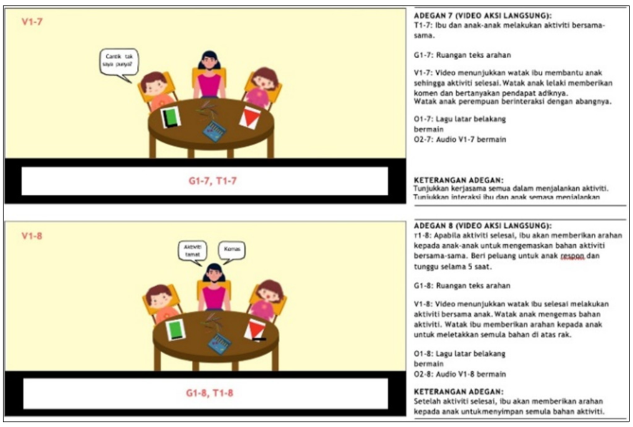

Fig. 6. Example of learning content module storyboard.

2) *Prototype 2*

Based on the feedback from Prototype 1, three new mock-up frames were designed to incorporate the changes requested. In total, there were 148 frames. The second prototype evaluation was carried out on May 22, 2022, involving 10 stakeholders from NASOM to verify the requirements and changes requested in Prototype 1. Table VII summarizes the feedback gathered during the Prototype 2 evaluation.

TABLE VII. FEEDBACK FROM PROTOTYPE 2

Module	Evaluation Feedback	Revised requirements
1 - Student Information	Allow Teachers to upload documents in the Student account, such as Diagnosis letters, etc.	Add an upload function to the student account.
5 - IEP Meeting	Add the Generate Invitation Letter function in the Set Meeting Appointment screen	Add the function
	Add a Remark column in the Set Meeting Appointment screen for Teachers to write if they send the invitation letter and Parents reply to the invitation manually	Add the column for the notification
	Remove the Meeting Participant label. Make it like sending an email	Modify the label
	Add the View Appointment button in the Generate Reply Slip screen, where the system will allow the Teacher to view or update any information regarding the Meeting	Add the button
	Add Disclaimer in Set IEP Meeting Appointment screen and manual Invitation Letter, if after a week, there is no response from Parents, the IEP will be automatically accepted and agreed	Add the notification
	The meeting outcome does not need verification/approval from the coordinator	Remove the verification/ approval condition
	Add the Upload button in the Record Meeting Feedback screen for teachers to upload any document related.	Add the upload function
6 - IEP Implementation	Add new attributes in the Record Activities screen, such as Assigned Teacher, and Relief Teacher	Add the attributes in Record Activities
	Need to ensure the names of assigned and relief teachers, which are displayed in the Activities Summary Report	Add condition for verification
	Allow teachers to upload any extra material in multimedia learning content	Add the upload function
7 – IEP Progress Review	Remove processes Modify IEP Progress Review and Parents Review - IEP Progress Review	Remove the two processes
8 – Annual Progress Report	Change the term Manage IEP Progress Report to Annual Progress Report	Modify the term
	Change the term Approved to Verified.	Amend the term
	For parents, use the term Accepted and Agreed	Modify the term
	For teachers, use the term Reported by	Modify the term
9 – User Management	Under Coordinator roles, add a screen to assign certain Students to their Teacher, where the Coordinator can assign a substitute teacher for that Student if their teacher is on leave	Modify the screen
	Add a Leave Record screen for the Coordinator and the Teacher	Add a new screen for the Leave Record

In total, 18 feedbacks were obtained. Notably, the IEP Meeting module had the most revised requirements, especially in terms of add and remove capabilities. Similar to Prototype 1, feedback from Prototype 2 uncovered many incomplete requirements in the Student Information, IEP Meeting, IEP Implementation, Annual Progress Review, and User Management modules. Two processes in the IEP Progress Review module were removed. Other changes emerged from the standardization of terms to be deployed and the user interface design. After incorporating all the feedback from Prototypes 1 and 2, the design, storyboards, and documentation were finalized for the development phase. This iterative prototyping approach enabled thorough refinement to be made to the final prototype, enhancing its functionality and quality.

C. *Development*

1) *CIIP System Architecture*

The Model-View-Controller (MVC) architecture pattern was implemented for the CIIP system architecture, as it allows users to be isolated from business logic and application components to be independently deployed and maintained [22-23]. This architecture pattern enabled smart recommender, interactive learning modules, a monitoring system, and tracking the progress of children with ASD, as exhibited in Figure 7.

2) *CIIP Sitemap*

Figure 8 provides a visual representation of the structure of CIIP, acting as a guide to help users navigate pages, functions, and content. Each function in the sitemap is associated with more than one use case from the respective diagram. Table VIII maps each function to relevant use cases available in CIIP.

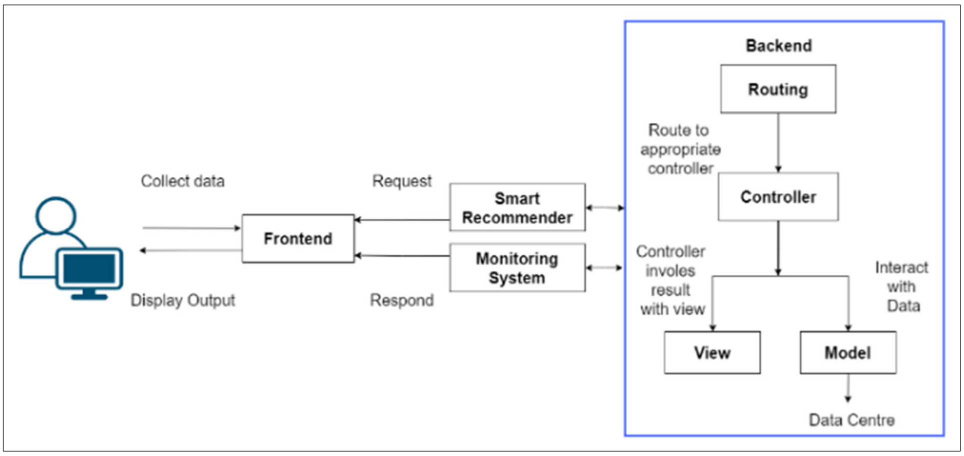

Fig. 7. CIIP system architecture.

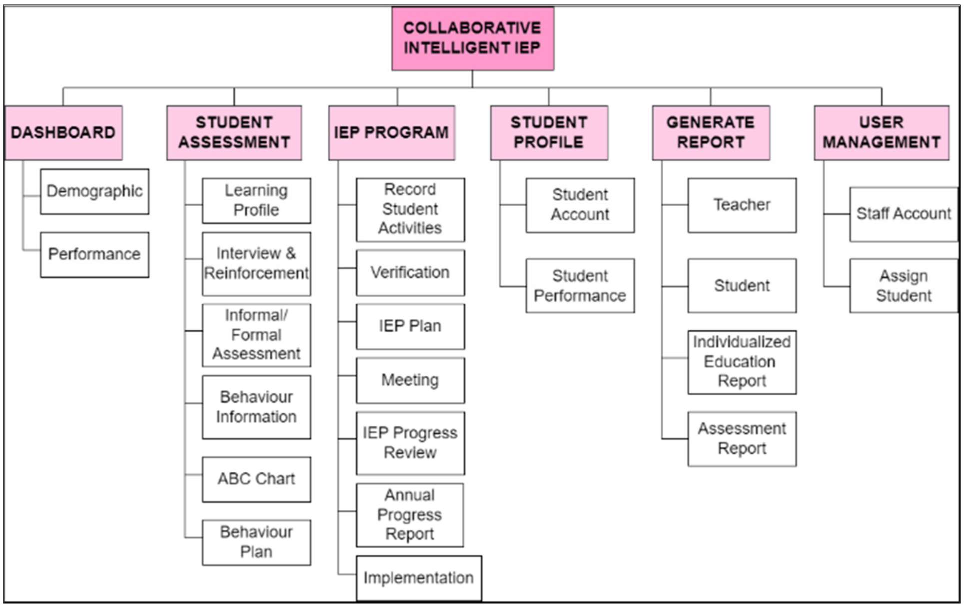

Fig. 8. CIIP sitemap.

TABLE VIII. MAPPING BETWEEN SITEMAP AND USE CASES

Function	Description	Related Use Case
Student Assessment	• Manage Interview and Reinforcement Form during the interview session • Record an assessment with the student to identify his level • Record, update, and view the Student behavior information, ABC chart, and Student behavior plan	• Manage Interview and Reinforcement Form • Record informal/ formal assessment and Student level • Manage Student behavior information • Manage ABC chart • Manage behavior plan
IEP Program	• Record, generate, and verify the IEP plan • Set an appointment with the Parents at the IEP meeting • Review and agree on the modification of IEP • Record Student activities in the DTT, Task Analysis, PRT, and FR datasheets • Update the progress of the Student in their own IEP • Create/update the annual progress report for Student's progress	• Manage IEP plan • Generate IEP plan • Verify IEP plan • Set meeting appointment •Confirm attendance • Modify IEP • Review IEP • Record Student activities • Update IEP record • Manage IEP progress review • Manage annual progress report
Student Profile	• Manage Student profile and permission • View the Student's performance level	• Register new student • Manage student profile
Generate Report	• Generate and view progress reports by Student, Teacher, and IEP • View assessment reports by Student	• Generate IEP • Generate activity summary • Manage IEP progress review • Manage annual progress report • Generate summary report
User Management	• Manage staff accounts Students • Assign Student to Teacher	• Manage Staff account • Manage Student profile
Chatbot	• Help Teachers and physiotherapists address autism-related content	• Send enquiry

3) *Design of Smart Recommender*

A smart recommender function was incorporated into CIIP to assist teachers in deciding on the learning modules for autistic children. This recommender function is an automated decision based on the inference engine developed using knowledge-based symptoms and a database of education needs. The Natural Language Processing (NLP) approach was adopted to recommend learning modules on the basis of the textual assessment report of all the experts involved. The smart recommender function is designed according to the STAR curriculum, and Figure 9 reveals its flowchart. The recommender function starts when a teacher submits formal or informal assessments by clicking the Recommend Assessment button. The system computes the total number of the completed tasks from the student's achievements and performance, identifying tasks where performance is completed. Subsequently, it calculates the number of tasks to be recommended based on a formula considering the student's minimum and maximum achievable tasks during the assessment. This formula incorporates predefined values determined by studying student patterns in the STAR curriculum. Referring to a sequence list organized by task priorities, the system iteratively evaluates each task's recommendation status until the desired number is reached. If a student passes a task, it accordingly reduces the recommended task count, and if they fail, it increases the count. Once the recommended task count reaches zero, the system displays the recommended tasks for the student.

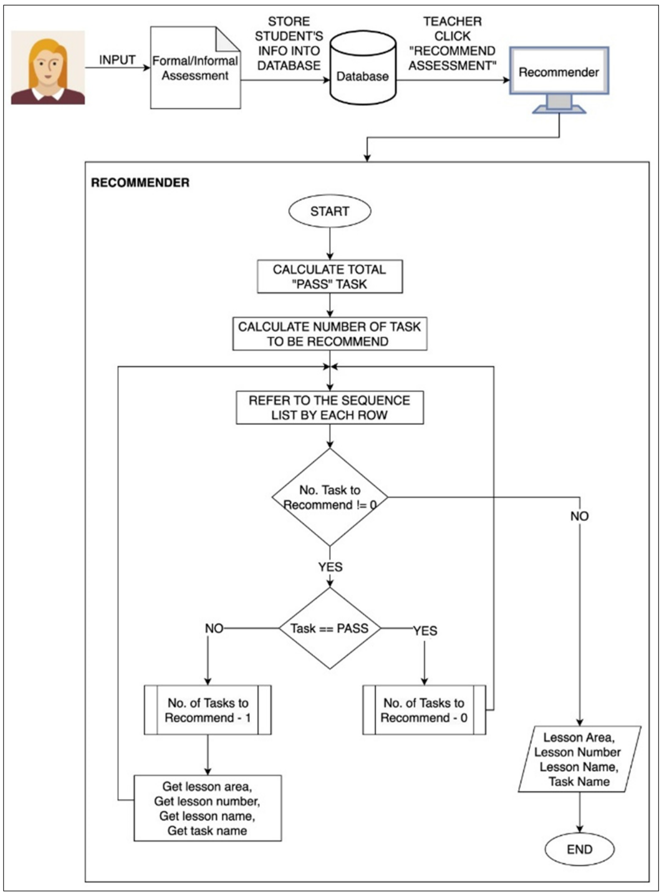

Fig. 9. Smart recommender flowchart.

D. *Testing Results*

Four external testers were recruited to carry out a functional test. In total, there were 263 test cases designed for the ten modules. Table IX summarizes the total number of pass and fail test cases found by the testers. On the whole, the four testers reported 77 failed test cases. However, a further analysis of the test results found 15 duplicate issues, resulting in a total of 63. For these test cases, the testers reported 124 issues. Table X lists the distribution of the severity for the failed test cases in the 10 modules. The severity was determined by the developers. Five failed test cases were considered critical and 22 were regarded major. The other 22 and 14 failed test cases were classified as medium- and low-severity, respectively. The issues found were classified as access control, functional, validation, and performance. An example is the system's ability to record a meeting feedback multiple times, even after it has already been recorded once. Another example is a delay in receiving email notifications, indicating a potential issue with the system's notification mechanism.

TABLE IX. TEST EXECUTION STATUS OF FOUR TESTERS

Tester#	Total tests executed	Passed test cases	Failed test cases	Number of issues found
Tester 1	263	253	10	30
Tester 2	263	235	28	40
Tester 3	263	258	5	21
Tester 4	263	229	34	33

TABLE X. DISTRIBUTION OF DEFECT SEVERITY ACROSS THE 10 MODULES

Module	Total test cases	Pass test cases	Severity				Total failed test cases
			Critical	Major	Medium	Low	
1	31	21	2	3	2	3	10
2	18	11	1	3	3	0	7
3	15	6	0	3	4	2	9
4	50	40	0	4	2	4	10
5	57	53	0	3	0	1	4
6	31	25	1	0	5	0	6
7	15	12	0	3	0	0	3
8	13	10	0	0	3	0	3
9	30	19	1	3	3	4	11
10	3	3	0	0	0	0	0

Only Module 10 (Chatbot) had no failed test cases, whereas Module 9 (User Management) had the highest number of failed test cases. Although Module 10 had no failed test cases, it had the most new additional requirements. Obtaining requirements for a chatbot can be challenging at the early stage of development, as evidenced by the lack of feedback received during the evaluation of prototype 2. This is likely because stakeholders may not have a clear idea of what they want the chatbot to achieve or how it should function. The main new additional requirements were the chatbot to be placed on the login and homepage and a dashboard that enables the coordinators, teachers, and parents to monitor the student's progress.

The other problematic modules were Module 1 (Student Information) and Module 4 (IEP Plan Development), with 10 failed test cases for each. The high number of issues found in Modules 1, 4, and 9 is probably due to the complex process flow between these modules, for which these issues could not be discovered earlier through visual representation during the prototype evaluation. To support the drawback of the prototype approach in handling complex processes, the use of Business Process Management (BPM) tools, such as the Bizagi modeler, is suggested to enhance the visibility of the workflow between processes [24-25]. IEP implementation had some issues during the functionality test although their number was relatively low. This is because the requirements changed many times since the prototype evaluation. From the 63 failed test cases, 31 requirements needed to be revised, and 17 new ones were added to fix all of them. Tables XI and XII summarise the revised and the additional requirements, respectively. Many of the revised requirements originated from Modules 4, 6, and 7 and were due to the modification of the user interface to support the changes in the forms and datasheets.

IV. CONCLUSION

CIIP is a comprehensive collaborative intelligent IEP for each child with ASD, tailored based on experts' assessments and progress reports. CIIP consists of three main module categories, which are the personalized educational platform, the learning modules, and the report and monitoring system. CIIP will be utilized by the NASOM teachers, therapists, parents, and caretakers of the children with ASD. It is important for the autism community to always have informed data on children's learning progress for easy monitoring and fast action. CIIP can also be utilized by special education schools and therapy centers.

TABLE XI. SUMMARY OF REVISED REQUIREMENTS

Module	Number of revised requirements	Description of revised requirements
3 – Intervention/ Educational Assessment	1	• Revised formula in the recommender.
4 – IEP Plan Development	9	• Remove the review dates 1,2, and 3 • There cannot be the same lesson under the same IEP plan • Modify the IEP plan form • Print the IEP plan as a whole • Student behavior information, ABC chart, and behavior plan should be linked together • ABC chart can record the misbehavior of the student many times according to target behavior
5 – IEP Meeting	2	• Modify the letterhead in the invitation letter
6 – IEP Implementation	7	• Modify DT datasheet form • Modify the PRT datasheet form and add the calculation formula • Modify the FR Datasheet form and add the calculation formula • Modify task analysis datasheet form
7 – IEP Progress Review	8	• Add title, review date, and period under review • Lessons that have been planned in the IEP plan should be directly displayed in the IEP progress review • Print the IEP progress review as a whole • The Coordinator should approve the IEP progress review as a whole, but revert the lessons one by one
8 – Annual Progress Report	4	• Lessons that have been planned in the IEP plan should be directly displayed in the annual progress report • Print the annual progress report as a whole • The Coordinator should approve the annual progress report as a whole, but revert the lessons one by one

TABLE XII. SUMMARY OF ADDITIONAL REQUIREMENTS

Module	Number of additional requirements	Description of Additional Requirements
1 – Student Information	2	• Change the authorization for register new Parent/ Student from Teacher to Coordinator • Super admin, Coordinator/Assistant Coordinator, and Teacher can edit their profile information
9 – User Management	4	• Super admin can view the Student and Parent's details for each NASOM center • Super admin and Coordinator can view and delete the IEP plan, IEP progress review, etc. • Super admin can create/view or delete the NASOM center • There should be a view and restore button in the list of Students or Staff that have been deleted
10 – Chatbot and Avatar	9	The following details about the position of the chatbox in the CIIP system: • NiA will be located on the right-hand side of the login page • On the right-hand side of the homepage after the user login to the system, NiA will greet each one of the users including Coordinators, Teachers, and Parents • If a user navigates through the system and returns to the homepage, NiA will change to a sit-down position for Coordinators, Teachers, and Parents • If the user clicks on the Chat with Us button to interact with the chatbot, NiA will change its position to show the chatbot • When interacting with the user in the chatbot, NiA will be in an icon/symbol avatar
11 – Dashboard	4	• The coordinator is authorized to view the demographic, student performance, percentage of correct responses by category for the DTT datasheet, percentage of score category for the PRT datasheet, number of independence per task/day, and number of task prompts per day for FR datasheet for the Student who enrolled in the center under that particular Coordinator • The Teacher is authorized to view the demographic, Student performance, percentage of correct responses by category for the DTT datasheet, percentage of score category for the PRT datasheet, number of independence per task/day, and number of task prompts per day for FR datasheet for the Student that has been assigned to them • Super admin is authorized to view the demographic, Student performance, percentage of correct responses by category for the DTT datasheet, percentage of score category for the PRT datasheet, number of independence per task/ day, and number of task prompts per day for FR datasheet for Students in all NASOM centers • Parents can only view their children's performance

CIIP was developed following the prototyping approach that included initial requirements gathering, design, prototyping, customer evaluation, refinement, and testing. The system's functionality across several modules was comprehensively outlined in use-case diagrams, which were created by capturing the initial requirements through process flows. The prototyping approach plays a critical role in visualizing these requirements, obtaining stakeholders' feedback, and iteratively improving the design. The system design underwent multiple revisions and improvements as a result of the two prototypes and subsequent stakeholder evaluations. The development phase incorporated the finalized design and requirements into the CIIP system architecture engaging the MVC pattern for modularity and maintainability. The testing phase thoroughly assessed functional aspects, identifying and resolving issues with access control, validation, and performance across all modules.

Although the prototyping approach may not be suitable for developing complex systems with interrelated modules, such as CIIP, it allows stakeholders to provide early feedback in the development process, helping to refine the requirements and design before the system's final development. Visualization of the system encouraged better collaboration among development teams, stakeholders, and users to identify issues, clarify requirements, and discuss effective solutions. To better understand the system requirements of module interactions, a comprehensive business process modeling could be defined earlier in the development process utilizing process mapping, flowcharts, or UML diagrams. Knowing how modules interact and interdepend can promote consistency in the design and minimize reworks.

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