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Su objetivo principal es la divulgación del quehacer académico de la investigación y las prácticas docentes inmersas en la informática y la computación, así como las diversas vertientes de la tecnología educativa desde la perspectiva de la informática y el cómputo, en la que participan investigadores y académicos latinoamericanos.

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EDITORIAL

Tecnología Educativa Revista CONAIC en su tercer volumen, se encuentra integrado por investigaciones académicas desde la perspectiva de la computación y la informática con un impacto internacional de alta calidad científica con relación a la Construcción de Literacidad Digital a partir de Objetos de Aprendizaje Offline; the Design of a methodological strategy for the inclusion of university students with ASD in ICT educational programs; the Coping strategies effectivity in students with language disorder, role stress in students; the Profiles of coping strategies used by dyslexic student at university level; el Jigsaw Colaborativo con Realidad Aumentada para Geografía de Primaria: Propuesta de Prototipo con los 5 Municipios de Baja California Sur; The Metaverse and Digital Art for Artistic Inclusion Through NFTs; the Use and effectiveness of inclusive technologies in decentralized technological institutes in the state of Veracruz, México; the Generative AI Facilitating Image Recognition for the Visually Impaired in Online Learning; the Gamified tangible interfaces with artificial intelligence to improve emotional skills in children with autism and the Educational Electronic Prototype to Support the Learning of Braille.

Tecnología Educativa Revista CONAIC se consolida como un espacio académico y científico de excelencia nacional e internacional. Su propósito es fortalecer la transmisión del conocimiento mediante enfoques innovadores, adoptando una visión contextual y transdisciplinaria que integra la computación, la informática y la tecnología educativa.

LOS EDITORES

Construcción de Literacidad Digital a partir de Objetos de Aprendizaje Offline Building Digital Literacy from Offline Learning Objects

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Resumen. Esta investigación es un estudio disciplinario en Tecnología Educativa de enfoque cualitativo con diseño metodológico combinado de Investigación-Acción y Etnografía Digital, realizado en un centro escolar de El Salvador. La pregunta de investigación se concibió a partir del contexto del confinamiento por el COVID-19 y la necesidad de construir literacidad digital. Desde esa perspectiva se propuso el diseño de la propuesta e implementación en cinco etapas de un marco metodológico que incluye una plataforma de un repositorio de Objetos de Aprendizaje sin conexión a internet, bajo el supuesto que, precisamente, el acercamiento intencional de esta propuesta, aumenta las posibilidades de desarrollar literacidad digital en esos estudiantes. La información recolectada arrojó resultados que sugieren que el acceso a los recursos tecnológicos que la alfabetización digital promueve, debe ser equitativo al proceso de formación para lograr usar esas herramientas de la forma crítica que la literacidad digital busca.

Palabras Clave: Tecnología Educativa, Literacidad Digital, Objetos de Aprendizaje, Conectividad.

Summary. This research is a qualitative, disciplinary study in Educational Technology with a combined methodological design of Action Research and Digital Ethnography, conducted in a school in El Salvador. The research question arose from the context of the COVID-19 lockdown and the need to develop digital literacy in a public elementary school. From that perspective, the design and implementation were then proposed, in the same five stages of the methodological framework that includes a repository platform for offline Learning Objects, under the assumption that, precisely, the intentional approach of this proposes, increases the possibilities of developing digital literacy in these students. The collected data suggests that access to the technological resources promoted by digital literacy must be equitable to the learning process in order to achieve the critical use of these tools that digital literacy seeks.

Keywords: Educational Technology, Digital Literacy, Learning Objects, Connectivity.

1 Introducción

La educación ha sido un tema de conversación, de investigación y de acción en todas las sociedades en su largo camino de constituirse como se conoce en la contemporaneidad. Instalar capacidades, el desarrollo de habilidades ha sido la premisa que ha alimentado su estrecha relación con el progreso de las comunidades, y más aún, en tiempos en los que se ha vinculado tan estrechamente con la tecnología como vehículo. En esa conexión, el ejercicio de la criticidad, más allá del instrumentalismo, se evidencia y se demanda en las actuales formas de información y comunicación, por lo que es importante estudiar como desde la escuela, se están creando las posibilidades para que la literacidad digital se maximice.

La presente investigación recogió evidencias de la necesidad de fortalecer la literacidad digital en tiempos de la pandemia del COVID-19, que activó la modalidad a distancia en las escuelas salvadoreñas desde inicios del año 2020. Sin embargo, este contexto evidenció la desventaja para las comunidades menos favorecidas que corren el riesgo de no adaptarse y así abrir más su brecha de desigualdad. Fue menester recuperar las formas de los Objetos de Aprendizaje de las escuelas públicas rurales que no han tenido acceso regular a internet para implementar la virtualidad, especialmente durante el período de cuarentena como en este caso del Centro Escolar Cantón El Progreso (CECEP), en Morazán, El Salvador.

Con los lineamientos anteriores, se recorre la travesía de alrededor de tres años en los que el investigador, en conjunto con los demás participantes de esta escuela rural, estudiantes, profesores, asesor de tesis e institución a cargo del doctorado, recogieron insumos para documentar el proceso investigativo del fenómeno de estudio que es la literacidad desde los Objetos de Aprendizaje sin conexión a internet, y donde al final del año 2024 satisfactoriamente me permitió obtener el grado de Doctor en Tecnología Educativa.

Del mismo modo, se determinó los Objetos de Aprendizaje como el objeto de estudio y luego las preguntas se establecieron desde un proceso de revisión coherente con el diseño de Investigación-Acción y sus etapas en el sentido de la propuesta de la plataforma repositorio “Sentipensante”, en coherencia con el propósito general. Esto

en combinación con la Etnografía Digital desde el estudio de la interacción del usuario con los recursos de la misma propuesta. Esta plataforma sugirió un espacio de pensamiento crítico a partir de la interacción del estudiante en su rol de internauta, con la diversidad de textos que las Tecnologías de Información y Comunicaciones (TIC) ofrecen en la actualidad sin esa dependencia a internet, pero sí con la posibilidad de ensayar la forma de interpretar, analizar y crear a partir de los múltiples formatos de textos digitales, de esos recursos.

También se fundamenta con la justificación que pretende aclarar por qué la relevancia de este tema en esta época de cambios y hasta de incertidumbre, las razones prácticas, teóricas y metodológicas de dicho proyecto investigativo y la propuesta hacia el debate epistemológico que se pretende robustecer. El propósito principal es proponer una plataforma a manera de repositorio de objetos de aprendizaje sin conexión a internet en un formato familiar, pero con guías intencionales de aprendizaje hacia la autorregulación.

2 Marco Teórico

2.1 Literacidad y Criticidad más allá de la Alfabetización

A lo largo de la historia del ser humano letrado, el proceso de adquisición de la capacidad para comunicarse de forma escrita ha venido evolucionando de acuerdo con su contexto social, geográfico y cultural. Desde esta perspectiva, la escritura en sí es lo que ha determinado a la historia conocerse con ese nombre en modernidad y distinguir entre los eventos antes y después de los primeros registros de escritura. Naturalmente, ese proceso de la escritura, para constituirse como tal, ha tenido su ritmo, su propia constitución, diferentes nombres, diferentes enfoques hasta llegar a ser la lectura y escritura como se le conoce hoy y así seguirá evolucionando. Tal evolución estará sujeta a las necesidades comunicativas de las sociedades de las cuales habrá usuarios a favor y otros en contra. Esos cambios pueden comprender desde el núcleo de los idiomas, el nombre de los canales comunicativos, su aprendizaje, su utilidad, la cotidianidad de su uso y hasta los medios de cómo aplicarla. La lectura y la escritura como parte de un idioma no son estáticas.

Abonando más a esta idea del uso de la palabra como herramienta emancipadora, se ha venido pensando y repensando el acto pedagógico de aprender a leer y escribir de una forma más dinámica, más creativa, más útil. Pues de esa necesidad de transformación continua y necesaria, que genera la necesidad de transformación social, se desprende el concepto literacidad, del término anglosajón literacy, adaptado al español desde inicios de la década de los 2000, por el lingüista barcelonés Cassany citado por [1] al no encontrarse un término justo y equivalente en su idioma, pero con la misma orientación trascendental de la lectura y la escritura y enfocando en el individuo como un ser capaz y dispuesto.

En [2] se indica que los colegios de habla hispana han introducido el término “literacidad” en lugar de alfabetización, en este sentido, en un más estudio reciente, por ejemplo, en [3] se menciona el término alfabetización de la siguiente forma:

Denominamos “alfabetización” al periodo que comprende los grados de primaria baja (primero, segundo y tercero). En las aulas multigrado, los profesores trabajan con alumnos no alfabéticos, que habitualmente ingresan a primer grado y, a su vez, con los que se apropiaron de la relación sonido-letra implicada en el principio alfabético del sistema de escritura, pero continúan aprendiendo otras convenciones del sistema como la segmentación entre palabras y la ortografía (p. 3).

Como se puede observar, en cada hito histórico, la literacidad ha jugado un papel importante, por lo que no es raro que ahora con la revolución tecnológica esto también sea un tema de interés. Se concibe a las habilidades de lectura y escritura con criticidad dentro de las que en otros estudios se definen como competencias digitales, así otros conceptos como el hipertexto y la hipertextualidad en la amplia gama de ofertas de contenido que la apertura de internet ofrece a sus internautas.

Finalmente, en cuanto a la investigación en literacidad, de acuerdo con [4] esta persigue la comprensión, descripción e interpretación de la relación entre el conjunto de interacciones de construcción de significado y las prácticas sociales y culturales del entorno en que ocurre un evento de literacidad [5].

2.2 Tecnología Educativa

Las TIC han estado presentes en las aulas por varias décadas desde sus orígenes en Estados Unidos a comienzos del siglo XX. En muchos contextos urbanos, rurales, públicos, privados, formales y no formales, más allá de la moda de usar dispositivos para hacer más llamativas las conferencias, se ha potenciado su uso con la

forzada demanda de la educación a distancia en línea. Trascendiendo la referencia histórica, la UNESCO considera que estas tecnologías pueden complementar, enriquecer y transformar la educación.

Desde luego y como ya se ha mencionado numerosas ocasiones, las escuelas como se conocía antes de la pandemia, ha sobrevivido gracias al uso de las TIC y de la flexibilidad de sus participantes hacia las nuevas formas de reunión. Sin duda, la hibridación de un enfoque educativo será inevitable, la conectividad a internet será esencial y la capacidad de adaptación de las nuevas metodologías marcará la diferencia entre el éxito o fracaso de esas nuevas formas [6].

Se vuelve relevante destacar los cambios conceptuales y naturalmente de forma que la Tecnología Educativa (TE) ha adoptado a lo largo de las décadas. Este interés hacia los medios y recursos educativos se ha venido acarreado desde el tiempo de los sofistas griegos, Santo Tomás y Comenio que a su vez influenciaron a pedagogos como Pestalozzi, Montessori entre otros. Es decir, la relación entre el acto pedagógico y los medios o herramientas para optimizarlo, gozan de una historia muy estrecha.

Realizando una revisión de la literatura, sin duda nos podemos encontrar con muchas definiciones del concepto Tecnología Educativa (TE) donde el autor Cabero será citado, por ejemplo, [7] citando a Cabero, rescata el concepto de TE convenido a mediados de los 70 como:

Una forma sistemática de diseñar, desarrollar y evaluar el proceso total de enseñanza-aprendizaje en términos de objetivos específicos basada en las investigaciones sobre el mecanismo de aprendizaje y la comunicación, que aplicando una coordinación de recursos humanos, metodológicos e instrumentales y ambientales conduzcan a una educación eficaz (p. 82).

Sin embargo, dentro del contexto de la pandemia por COVID-19, podemos citar a [8] donde nos mencionan que en:

En tal sentido la Tecnología Educativa (TE) representa un término integrador al considerar la incorporación de diversas ciencias, tecnologías y técnicas, vislumbrándose como una disciplina viva, dada la amplia cantidad de transformaciones a las que se ha visto expuesta a lo largo de los años, como parte de los cambios resultantes del contexto; y donde ha cobrado incuestionable valor en tiempos de pandemia (p. 3).

Como se puede observar, la TE es y seguirá siendo una disciplina en constante reconceptualización. Justo en esa búsqueda más concreta de concebirla, se sigue buscando un diseño, una utilización y evaluación de las TIC aplicadas a acciones formativas, pedagógicas y didácticas.

Más allá de la historia de esta disciplina, en [8] analizan algunos problemas y retos de la TE en referencia al nuevo contexto social, ya que no es lo mismo hablar de esta en términos de la última década, mucho menos en el último quinquenio o yendo más reciente al último año. Si bien es cierto esta conceptualización y de cómo se lleva a la práctica, está viciada por perspectivas y diversos discursos, pero no se puede negar la omnipresencia casi total de la revolución digital en la constantemente cambiante sociedad informacional.

2.3 Objetos de Aprendizaje y Plataformas sin Conexión a Internet

Desde el término tecnológico de acuerdo con [9] citando a [10], un Objeto de Aprendizaje (ODA) se refiere a una gran variedad de recursos tecnológicos que proveen información, sin embargo, como bien lo menciona en las definiciones que presentan en [11], es un concepto versátil, en este apartado se proponen otras formas de reconceptualizar los ODA, desde el trabajo fuera de línea.

Volviendo entonces al origen, ciertamente es ahora cuando los ODA se conocen más por su versión de Objetos Virtuales de Aprendizaje (OVA), pero sí se vuelve al origen de su concepción como tal, no necesariamente dependieron de una red de conectividad para ser efectivos. Esto, puede también interpretarse de manera que todo recurso, todo material, toda ayuda didáctica que sirva a un propósito específico y que se pueda reutilizar en otros escenarios, no necesariamente conectados, es un Objeto de Aprendizaje. Esto significa que, desde la concepción de habilidades computacionales, que son básicamente la capacidad para pensar en un problema y las partes que lo componen para comprender, diseñar y evaluar soluciones individuales para dichos componentes, no necesariamente significa la necesidad inminente de una computadora o de una red para lograr la intencionalidad pedagógica de cada ODA y que muchos sitios y aplicaciones ofrecen sin conexión a internet [12].

En un ejemplo concreto, si es posible que un ODA como sería un meme a partir de su naturaleza social fenomenológica, puede representar esa réplica de contenido con uso pedagógico, que a su vez puede ser ajustado a los intereses que el autor decida o crea pertinentes a su contexto y propósito y que no necesariamente implica acarrear consecuencias legales por su uso, ya que es muy probable que el meme sea de dominio público, aunque no así el personaje o la persona en él. En esa libertad de uso, el propósito puede implicar niveles de pensamiento que aludan al sarcasmo, protesta, humor, reflexión y crítica social. Aquí justo conecta la idea que tácitamente, este hecho de reproducción de contenido puede visibilizar una de las debilidades de un nuevo modelo pedagógico en el sentido que su alta dependencia a la conectividad a internet. Es decir, sin conexión, es imposible viralizar

un meme, y de esa forma se volvería también imposible la reproducción de contenido con fines educativos. Este hecho sin duda invita a pensar en cuáles serían las alternativas de sobrevivencia de ese fenómeno de réplica.

Recientemente, se puede mencionar, donde autores como en [13], sugieren otros recursos como herramientas para la construcción y por consiguiente interacción con objetos de aprendizaje, donde no se requiere conexión a internet como Ardora y ExeLearning. Sin embargo, buscando una forma más manejable, autores como en [14] proponen utilidades similares a las wikis, que son plataformas colaborativas de construcción de conocimiento y de dominio público o incluso como Recursos Educativos Abiertos (REA) en la variedad de plataformas que ofrecen cursos gratuitos en línea y con ciertas funcionalidades fuera de línea.

3 Metodología

Esta investigación adopta un enfoque cualitativo con diseño metodológico combinado de Investigación-Acción y Etnografía. Es necesario resaltar que la Investigación-Acción no es un proyecto investigativo de corte neutral o distante entre el investigador y los participantes. Según [15], este diseño investigativo, desde la perspectiva metodológica refleja un antes y un después en los estudiantes, así como también les permite que aprendan solucionando problemas del contexto, fundamentalmente en escenarios reales. Sin embargo, este involucramiento no surge desde una mirada asistencialista en la que el investigador es visto como un erudito que lleva soluciones a las comunidades, sino más bien, construye las soluciones con el involucramiento pleno de los participantes en cada etapa del proceso.

Por otro lado, desde las condiciones del contexto en el que se inició este proceso de investigación en la observación del contexto y la problemática, se contempló que la forma más viable para la recolección de datos, debía ser la Etnografía Digital desde la conceptualización de [16] que es “la exploración de la interacción humana por las plataformas digitales en los dispositivos electrónicos (p. 110)”. Esta interacción es evidente desde el correo electrónico, especialmente entre docentes o con los estudiantes de niveles más altos, pasando por los tutoriales en los canales de YouTube y sin dejar a tras la interacción más directa en WhatsApp con videos, notas de voz, fotos y documentos en su diversidad de formatos, que son las unidades hermenéuticas [17] de esta investigación.

3.1 Participantes y Muestreo

Toda investigación de rigor académico que busca concebir nuevas propuestas en el tema que se desarrolle, deben contar con un fundamento de comprobación, de evidencia de la búsqueda de validación de sus supuestos desde y para su población meta. En el caso específico del CECEP, una escuela rural del sector público ubicada en el departamento de Morazán en El Salvador, la planta docente está compuesta por 9 profesores que atienden los niveles de primero a tercer ciclo o de primero a noveno grado de educación básica, que es lo mismo. Hasta agosto de 2021, se registraba una matrícula de 217 estudiantes, 145 niñas y 72 niños, en todos esos niveles del grupo etario entre 10 y 15 años. Sin embargo, por la composición del supuesto de esta investigación, por conveniencia se propuso alcanzar a la población de 149 estudiantes, 87 niñas y 38 niños, que estaban inscritos de cuarto a noveno grado, bajo la responsabilidad de seis docentes, extrayendo de ese universo una muestra significativa de ellos, de ambos sexos y con cierto criterio descrito más adelante.

Por otro lado, las unidades hermenéuticas fueron las piezas de correspondencia entre el docente y estudiante, las guías de estudio y sus respuestas en el trabajo escolar remoto o en línea o como se han denominado anteriormente, los Objetos de Aprendizaje.

3.2 Proceso de Recolección de Datos

En la Figura 1 se representa un diagrama del mapa de trabajo para la recolección de datos y la utilización de instrumentos, que se concibió desde a etapa preinvestigativa, en común acuerdo con la escuela de los participantes, en alineación con su calendario de actividades y que cuenta con la flexibilidad ante cualquier situación que demande cambios.

Este plan refleja la aplicación de las técnicas y sus instrumentos de recolección de datos distribuidos de manera temporal en cada una de las etapas del diseño de la investigación. Dependiendo de las características de este último, se aplicaron cambios a medida que la interacción con los participantes fue desarrollándose y de los acuerdos que vayan evolucionando con el informante clave que es el director desde sus antecedentes de conocimiento del contexto y de los antecedentes de los estudiantes en cuanto al fenómeno, así como los lineamientos de la institución de educación superior a la que este proceso investigativo está adjunto.

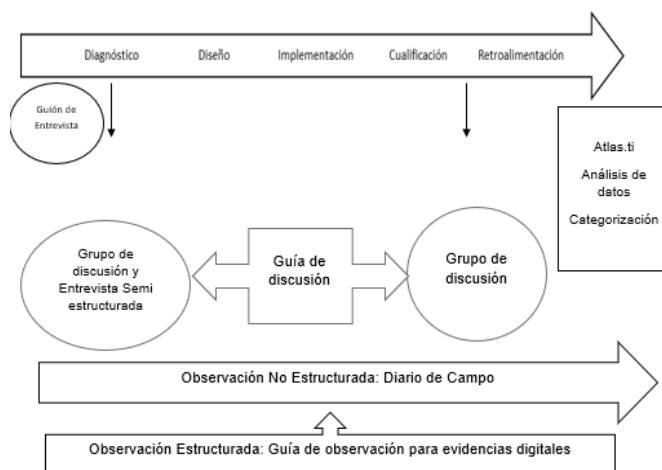


Figura 1. Plan de recolección de información y aplicación de instrumentos.

3.3 Análisis de Datos

Las herramientas digitales pueden disponer de funcionalidades relacionadas con la búsqueda, organización, categorización y análisis cualitativo en datos estructurados y no estructurados en la vorágine de la misma subjetividad de la investigación cualitativa, en este caso el programa Atlas.ti.

El reto de darle sentido a todos los informes verbales, reducir en significancia hasta lograr una cantidad de unidades hermenéuticas manejables y todavía relevantes para luego estructurarlas y exponerlas para construir conclusiones más comprensivas. Estos datos van desde textos o imágenes, hasta objetos, vídeos o audio, con los que se trabaja hasta hallar patrones que ofrezcan respuestas a las cuestiones planteadas.

4 Resultados

A continuación, se exponen de manera descriptiva y a la vez comparativa con relación a la teoría, los descubrimientos arrojados en cada una de las etapas de ciclo de la Investigación-Acción, con la propuesta que se planteó en la planificación del proyecto, junto al resultado final en la implementación de este, según la Figura 2, con la intención de capturar toda la información posible.

La Figura 2 refleja el resultado pragmático final de cada una de las técnicas, instrumentos y de más herramientas que se utilizaron para la recolección, organización, análisis y presentación de los datos desde el trabajo de campo.

4.1 Diagnóstico

Para lograr concretar esta etapa de actividad presencial, fue necesaria una labor de coordinación con el director de la escuela, ya que, para ese entonces, las escuelas no habían vuelto del todo a su modalidad presencial de las actividades diarias. Este factor dificultó el contacto directo con estudiantes, pero es aquí donde la Etnografía Digital tomó su protagonismo al recoger insumos de manera remota y así ir recogiendo los insumos a partir de este contacto con los participantes.

Los participantes se concretaron en 3 estudiantes de 4º, 2 estudiantes de 5º grado, 2 estudiantes de 6º grado, 2 estudiantes de 7º grado, 2 estudiantes de 8º grado y 2 de 9º grado, haciendo un total de 13 estudiantes, diferente a la propuesta original que se sugería que fueran 2 estudiantes de cada grado, haciendo un total de 12. Esto como parte de la iniciativa del director e informante clave, en vista que alguno de los estudiantes citados pudiera faltar a la cita. Desde luego, aunque el número fue diferente, se contempló que todos cumplieran con los requisitos planeados, por ejemplo, que estuvieran matriculados y asistiendo activamente a clases regulares, que participaran de manera voluntaria, comprometidos a finalizar cada una de las etapas del proyecto.

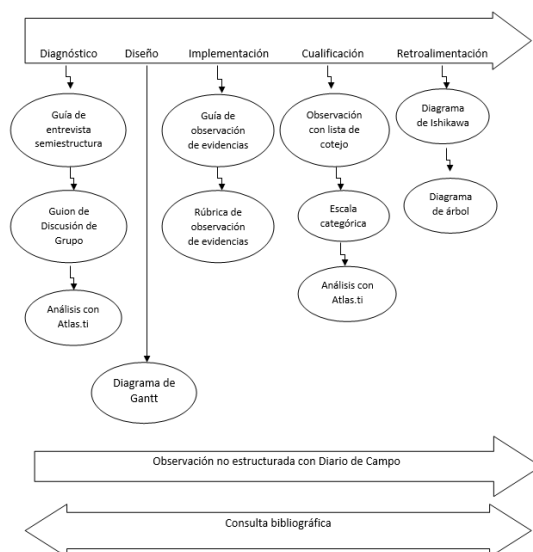


Figura 2. Resultado del Plan de Recolección y Análisis de datos.

Uno de los primeros descubrimientos de este primer encuentro, es que, a manera de canalizar la comunicación, se creó un grupo cerrado de WhatsApp, incluyendo al director, a los participantes y al investigador y eventualmente a parte del equipo docente. Esto, con el conocimiento inicial que, según los datos recogidos del grupo de 13 estudiantes, 12 de ellos contaban con un teléfono inteligente o al menos tenían acceso a uno y que intermitentemente tienen también conexión a internet. Este grupo se creó con el propósito de que el investigador pudiera recibir las evidencias directamente de los estudiantes, de cómo ellos mismos estaban recibiendo y respondiendo a las actividades y como estaban recibiendo retroalimentación de sus docentes y es así como se instaló el principal medio de recolección de evidencias. La premisa, es que no se recogieron esos insumos para valorarlos, si no para lograr identificar el nivel de comprensión de los estudiantes hacia estos y así la categorización desde la construcción de los ejes temáticos para su posterior análisis.

4.1.1 Entrevista Semi Estructurada

El recuento que las funciones básicas de Atlas.ti, reconoció 84 códigos o palabras concurrentes de las que se rescatan en la Tabla 1 las primeras cinco y las últimas cinco, también recorriendo las valoraciones desde las anotaciones del diario de campo con su obligatorio análisis en temporalidad tanto del momento de la captura del discurso, la transcripción y su posterior reflexión.

Tabla 1. Incidentes por código de cada categoría en el análisis semántico.

Categoría/Eje temático	Incidentes
Superiores	
Tecnología	5
Educación	3
Pandemia	2
COVID-19	2
Limitaciones tecnológicas	2
Inferiores	
Educación pública	1
Trabajo remoto	1
Acceso a la tecnología	1
Lectura: Falta de conectividad 1	1
Falta de formación 1	1

En la ejemplificación de la Tabla 1, se retoman 5 códigos, categorías o ejes temáticos como parte de las categorías superiores o con más incidentes y luego en el nivel inferior, otros 5, que son todas aquellas con menos referencias. Evidentemente hay un reconocimiento de aquellas categorías que afecta directa o indirectamente a las operaciones educativas del CECEP.

4.1.2 Discusión para Grupos

Esta entrevista se llevó a cabo luego de la reunión con el director, se reunió a los 13 estudiantes citados en el aula originalmente destinada para 9º grado de educación básica. El evento de recolección de información se extendió a una hora y media, considerando el tiempo de organización, recesos y refrigerio. También es relevante insistir con la idea que la convocatoria de los participantes fue un reto, primero en el sentido de los criterios de selección, ya que lo que resultó más difícil fue la apertura a la participación no solo en esta reunión inicial, sino mantener la comunicación constante para la recogida de las evidencias a lo largo de proceso.

El comentario más frecuente que señaló el director fue que los estudiantes “no querían comprometerse a más cosas que les quitaran más tiempo”. Es por eso por lo que en un inicio se pensó en realizar esta entrevista grupal en esta etapa de diagnóstico y otra de forma valorativa del plan de trabajo para considerar un antes y un después, pero el compromiso de los estudiantes no se extendió hasta ese punto. Además, que, de hacerse de esa manera, los 2 estudiantes de 9º grado ya no hubiesen estado en la escuela porque la visita fue al final del año lectivo y la escuela no ofrece bachillerato para haber podido dar continuidad al año siguiente con las siguientes etapas e incluso el resto de los participantes pudieran haber descontinuado su asistencia.

Volviendo a la versión de libre acceso desde los motores de búsqueda, Atlas.ti ofreció a esta investigación la posibilidad de categorizar, desde la identificación de los 71 códigos o incidencias del discurso de los entrevistados, hasta agruparse correspondientemente en lo que se convertirían en 6 categorías que resumen los ejes temáticos o sensibilizadores previamente fundamentados de este proyecto (ver Tabla 2).

Tabla 2. Categorías de agrupación de códigos en la discusión grupal.

Categoría	Interpretación
<i>Literacidad</i>	Este concepto usado desde la idea que es un eje globalizador de competencias digitales, comprensión lectora, literacidad tecnológica y hasta habilidades comunicativas fuertemente vinculadas a las habilidades de pensamiento, se reconocen en los códigos en todos los elementos que puedan relacionarse o de alguna manera entrecruzarse con el vocabulario identificado por el programa.
<i>Tecnología Educativa</i>	Desde la perspectiva que la TE es más que la mera instrumentalización de recursos para cumplir una tarea, se identifica esta categoría desde sus elementos más operativos hasta los más estructurales que se reflejan en el discurso de los entrevistados.
<i>Competencias del estudiante</i>	Son todas las formas de interacción exitosa que el estudiante tiene con las situaciones de aprendizaje y que a corto y mediano plazo son de utilidad para escenarios de resolución de problemas.
<i>Competencias del docente</i>	Son todas las formas exitosas que el docente construye en favor del éxito de los estudiantes en relación con los objetivos de aprendizaje.
<i>Educación y escuela rural</i>	Es el contexto que representa características retadoras para el cumplimiento de los objetivos de aprendizaje y que establecen variantes en cuanto al aprendizaje en comparación con otros contextos más privilegiados.
<i>Objetos de Aprendizaje</i>	Son todos los recursos, instrumentos, herramientas virtuales o digitales que sirven al cumplimiento de objetivos de aprendizaje.

4.2 Diseño del Plan de Acción

A partir de la premisa del apartado anterior, se presenta a continuación, como se planificó desde una perspectiva de cronograma como se presenta en la Figura 3, lo que suponía trabajar de forma orgánica de acuerdo con los hallazgos del diagnóstico. Sin embargo, como en todo escenario humano, surgió la necesidad de elaborar ajustes, en la etapa de implementación, se muestra el resultado final de la forma de implementación del plan de trabajo con este diseño como base.

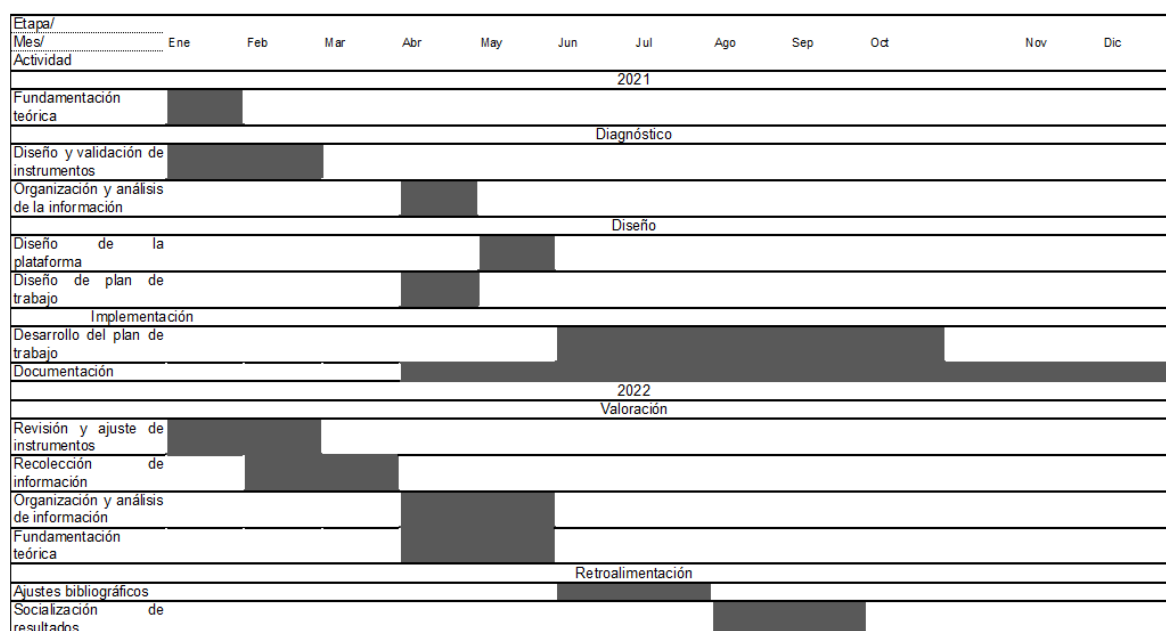


Figura 3. Proyección de actividades del proyecto investigativo 2021 y 2022.

El cronograma que se visualiza en la Figura 3, se presentó a la escuela como parte de la propuesta de trabajo del resumen ejecutivo del proyecto y desde el trabajo semipresencial y durante el proceso de implementación del plan de trabajo ciertamente se podría haber visualizado desde esta forma lineal, lógica de una etapa tras otra. Pero, desde luego que ya dentro del trabajo de campo a partir de los cambios que exige la realidad del contexto, surgen nuevas formas de planificación.

De esta forma, respondiendo a la pregunta correspondiente a esta etapa: ¿De qué manera se pueden integrar los Objetos de Aprendizaje sin conexión internet en la construcción de literacidad digital de los estudiantes de segundo y tercer ciclo del CECEP? Es básicamente por medio de la creación de la plataforma repositorio Sentipensante, que se diseñó desde elementos básicos de programación y con contenido relativo a la interacción de los estudiantes como usuarios de redes sociales y el fenómeno de la memética. Esta herramienta se instala en equipo ya existente y bajo el Diseño Instruccional, abren espacios durante los recesos para que los estudiantes puedan ejercitar su literacidad digital.

4.3 Implementación del Plan de Acción

En el contexto salvadoreño en la ruralidad, se caracteriza por la escasez de recursos, así como los ciclos continuos de analfabetismo o iliteracidad en todas sus modalidades ha permanecido más en estas zonas. De manera que, inherentemente es la escuela la que debe asumir esa responsabilidad como representante del proceso pedagógico institucionalizado. Como se ha insistido en los hallazgos anteriores, si los recursos son la principal limitante, se deben buscar formas en las que se pueda aprovechar lo que haya disponible de manera creativa.

Con esto en mente, se propuso una forma de usar el equipo de computadoras que la escuela ya tiene. No tenían conexión a internet, por lo que la propuesta inicial fue que se diseñara, se desarrollara y se instalara en cada equipo un programa muy parecido a plataformas como Microsoft Encarta, Microsoft Student Babylon o Dixio Desktop. Que son plataformas de carácter informativo, pero sin conexión directa a internet. Sí cuentan con una funcionalidad de conectividad para actualizaciones, pero no dependen del todo de esa conexión.

La variación de esta propuesta fue que el diseño fuera diferente en cuanto a los recursos, a los Objetos de Aprendizaje que tradicionalmente se había presentado. La innovación de estos recursos en esta plataforma era que se constituyeran por los formatos más comunes de los contenidos en las redes sociales, especialmente en Facebook, por ser la plataforma de mayor uso. Estos formatos incluirían, pero no se limitarían a memes, reels, historias y de más, con la idea que fueran creados desde y para los mismos consumidores, pero con la intencionalidad pedagógica que se desarrolló en espacios menos controlados que el salón de clases, sino en los recreos, como espacios para el ejercicio de la autorregulación, como parte de la literacidad digital.

4.3.1 Repositorio Digital de Objetos de Aprendizaje sin Conexión a Internet “Sentipensante”

Para la creación de la plataforma propuesta, que buscaba solventar o iniciar de alguna manera el proceso de solución de la problemática identificada desde lo estructural hasta lo operativo del CECEP, se diseñó y desarrolló un sitio con las ideas compartidas en el apartado anterior. Este sitio se depositó en una unidad de almacenamiento y así instalarse en el equipo objetivo.

4.3.2 Evidencias de la Rúbrica de Clasificación para Evidencias Digitales

Ahora bien, desde lo planteado que no se tiene un acceso directo a las actividades en su versión física en función de unidades hermenéuticas, son las capturas de pantalla las evidencias que se estudian a partir del diseño de los instrumentos. Cabe mencionar que el período de observación se dio desde abril hasta julio de 2022, recolectando un total de 60 muestras utilizando la Guía y el Diario correspondiente. En la Figura 4 se presenta una de ellas.



Figura 4. Capturas de pantalla como evidencia del análisis de Objetos de Aprendizaje.

4.4 Cualificación

4.4.1 Evidencias de la Lista de Cotejo de la Valoración del Plan de Trabajo

La forma final de completar esta valoración en general se dio desde julio a diciembre de 2022 como se detalla en el cronograma de implementación y que los retos ya mencionados no permitieron el progreso de otras formas más profundas de trabajo. Esta tabla se puede consultar en el enlace: <https://cutt.ly/CrwGrfk7>.

4.4.2 Escala Categórica

De la misma forma como se concretaría el principal propósito de construir una propuesta de acercamiento de esos objetos a estudiantes en estos contextos retadores, sí se diseñó y se implementó la plataforma Sentipensate, sin embargo, su éxito dependía no solo del investigador como observador activo, sino de un trabajo articulado a más largo plazo. Todo esto vinculado al propósito general que justamente ese acercamiento de estos recursos puede aumentar la posibilidad para que estos estudiantes desarrollen literacidad digital en funciones concretas como el autocontrol en el tiempo de consumo de contenido o la criticidad al momento de compartir noticias falsas, por ejemplo.

La forma en la que los resultados y siguientes pasos del ciclo de Investigación-Acción, se organizaron con la valoración de: insuficiente para una puntuación de 1 a 6, satisfactorio de 7 a 12 y destacado de 13 a 18; esto dependiendo de cuantos criterios hayan obtenido una respuesta afirmativa, en este caso 8 de 18 ítems.

4.5 Retroalimentación

4.5.1 Diagrama de Ishikawa

Rescatando la propuesta de [18] en referencia a la facilidad de los recursos gráficos para la estructuración de la información, a continuación, se presenta desde otra perspectiva, una herramienta para identificar la interrelación entre la causa y el efecto. Esto es con el objetivo de identificar los posibles impedimentos en el logro de los propósitos y las posibles implicaciones que estas vayan a tener en el problema estudiado en formato de retroalimentación positiva, es decir, ordenar la relación en medio de las implicaciones o causas, nos referimos al Diagrama de Ishikawa [19]. Entonces, se resumen en la Figura 7 del Diagrama de Ishikawa o Espina de Pescado los impedimentos y sus implicaciones en logro de resultados del plan de trabajo de este primer ciclo de las etapas de trabajo de la Investigación-Acción. De esta forma complementaria se ofrecen diferentes recursos para guiar un análisis más cercano a la objetividad y en aras de hacer crecer las acciones tomadas en esta intervención. De alguna manera, el diagnóstico ya visibilizaba impedimentos e implicaciones del plan de trabajo en relación con el logro de los propósitos, pero es ahí donde la flexibilidad de la Investigación-Acción juega un papel fundamental.

La Figura 5 desglosa entonces que estos retos fueron los factores para que las respuestas a las preguntas, el logro de los propósitos y la comprobación o refutación de los supuestos en su función de explicación al fenómeno de estudio, en consecuencia, no se cumplieron de manera completamente satisfactoria.



Figura 5. Diagrama de Ishikawa o Espina de Pescado de los retos identificados en las etapas de este ciclo de la Investigación-Acción.

Desde el análisis de los aciertos y desaciertos, se ubican estos factores antes mencionados, siendo las siguientes las que mayor incidencia tuvieron en todo el proceso en la búsqueda de la respuesta de la pregunta ¿Qué lecciones aprendidas deben priorizarse en la etapa de retroalimentación de la plataforma de Objetos de Aprendizaje sin conexión a internet con relación a la contextualización para estudiantes de segundo y ciclo del CECEP?:

- **Enfoque participativo:** Desde la funcionalidad participativa de la Investigación-Acción se buscó el involucramiento de los participantes de forma más significativa en las 5 etapas, pero en su causa, no se realizó de esa forma debido a los retos que en apartados anteriores se han descrito, teniendo como consecuencia un proceso centralizado en el investigador y el informante clave.
- **Calendarización:** La libertad que la Investigación-Acción permite, consideró como causa esa flexibilidad en el diseño e implementación del plan de trabajo, teniendo como consecuencia una vorágine de cambios constantes, en ocasiones poco productivos en referencia a las guías de la investigación.
- **Visitas presenciales:** Aunque la Etnografía Digital fundamenta el uso de recursos digitales en su función antropológica, siendo la conectividad a internet uno de los principales retos de la comunidad, la comunicación a distancia no fue precisamente una fortaleza, causando así la necesidad de visitas presenciales con poca estructura técnica como consecuencia.

5 Conclusiones y Trabajos Futuros

Con el objetivo de la construcción de literacidad digital, se realizó una propuesta en una primera versión de la plataforma Sentipensante que acercó a los estudiantes de educación básica del CECEP a Objetos de Aprendizaje sin conexión a internet, sin embargo, tiene oportunidades de mejora que pueden ser consideradas en un próximo ciclo de la Investigación-Acción en esta escuela rural.

De forma general, como parte de los objetivos de esta investigación, se logró:

- Diagnosticar el uso de Objetos de Aprendizaje de los estudiantes de segundo y tercer ciclo del CECEP: Sí se realizó el respectivo diagnóstico del cual se presentó abundante información a pesar de las limitaciones de movilidad y retos administrativos en la transición de la dirección de la escuela, así como se diseñaron los respectivos instrumentos cualitativos y el análisis con el software. Las técnicas e instrumentos no necesariamente arrojaron evidencias para el supuesto del uso de Objetos de Aprendizaje hacia la construcción de literacidad digital, pero sí la forma de las metodologías en general en el cambio de la presencialidad a la virtualidad durante el período de postpandemia.
- Diseñar una plataforma repositorio de Objetos de Aprendizaje sin conexión a internet para los estudiantes de segundo y tercer ciclo del CECEP: Se diseñó la plataforma Sentipensante desde el modelo de Diseño Instruccional de Taxonomía de Bloom, con recursos visuales y preguntas guía en dirección a productos concretos de lectura, escritura y diálogo. Sin embargo, esta construcción no permitió la consolidación del supuesto que esta plataforma se construye de forma colaborativa y a partir de la realidad, sino que fue centralizada en la experticia del investigador.
- Implementar el uso de una plataforma digital a partir de Objetos de Aprendizaje sin conexión a internet de forma autorregulada con estudiantes de segundo y tercer ciclo del CECEP: Se realizó la instalación de la plataforma Sentipensante en los dispositivos disponibles y se compartieron Objetos de Aprendizaje sin conexión a internet en espacios fuera de clase, menos controlados.
- Valorar la interacción de los estudiantes de segundo y tercer ciclo del CECEP con los Objetos de Aprendizaje de la plataforma sin conexión a internet en relación con el desarrollo de literacidad digital: Se realizó un proceso constante de reflexión sobre la práctica desde la Etnografía Digital, no se realizó de la forma participativa y colectiva como lo sugiere la Investigación-Acción, pero sí desde las evidencias recogidas en capturas de pantalla de la interacción de los estudiantes con los Objetos de Aprendizaje y bajo el supuesto que promueve la autorregulación en la interacción de contenido multimedia en los estudiantes con relación a la metodología del proyecto, el tiempo y recursos.
- Retroalimentar la pertinencia de los Objetos de Aprendizaje de la plataforma repositorio sin conexión a internet con estudiantes de segundo y tercer ciclo del CECEP: Se realizó un proceso de recolección de las lecciones aprendidas y la estructuración de la recopilación de los aciertos como desaciertos, sin embargo, no se logró compartir con el liderazgo de la escuela para implementar medidas de mejora, ya que dependió en sobremanera de las autoridades regionales y de país. Ciertamente los Objetos de Aprendizaje pudieron mejorar y ser más pertinentes y coherentes con los objetivos de aprendizaje de cada uno de los grados involucrados, pero todos los retos en la viabilidad no permitieron que estos hallazgos fueran compartidos con la comunidad y que sirvieran como base para el siguiente ciclo de la Investigación-Acción. Esto, por ende, no permitió que el supuesto que el repositorio de Objetos de Aprendizaje sin conexión a internet estuviera en constante reconstrucción contextualizada a partir de la valoración y retroalimentación de la implementación.

En esta investigación se logró la confirmación del supuesto general que la aproximación intencional a Objetos de Aprendizaje sin conexión a internet aumenta las posibilidades de desarrollar literacidad digital en los estudiantes de educación básica en la ruralidad, sin embargo, depende justamente de eso, de las virtudes que la Tecnología Educativa puede ofrecer desde un Diseño Instruccional evidente y de acuerdo a los objetivos que cada contexto requiere, es decir, en ese punto si difiere de los fundamentos teóricos, que no necesariamente hacen alusión suficiente a la adaptación de necesidades como las enfrentadas en un contexto rural, sino que asume, por ejemplo, se da por sentada la conectividad a internet y eso genera una dependencia inminente al acceso a recursos actualizados y de calidad

Como trabajos futuros, se tiene considerado experimentar con nuevas tecnologías que permitan crear objetos de aprendizaje que puedan ser utilizados sin conexión a internet, por ejemplo, Ardora, Exelearning, por mencionar

algunas, la restricción, porque en mi comunidad aún se encuentran escuelas públicas de educación básica sin conexión o acceso regular a internet.

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Design of a methodological strategy for the inclusion of university students with ASD in ICT educational programs

Diseño de una estrategia metodológica para la inclusión de estudiantes universitarios con TEA en programas educativos TIC

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Summary. The educational inclusion of students with autism spectrum disorder (ASD) in higher education poses both challenges and opportunities, especially in Information and Communication Technologies (ICT) programs, characterized by their high cognitive and technological demand. This paper proposes a methodological strategy oriented to the pedagogical accompaniment of students with functional ASD in ICT careers, with the aim of promoting meaningful learning, active participation and academic permanence. The proposal is based on a theoretical review, the analysis of real university experiences and the integration of international best practices. The strategy addresses curricular, technological, social and emotional dimensions in a comprehensive manner, seeking to ensure a more inclusive and equitable higher education. This approach seeks to establish solid foundations for the design of specific support for students with neurodevelopmental conditions, favoring their academic success. It also highlights the role of ICT as key tools to enhance motivation, engagement and autonomy, through the creation of adaptive learning environments sensitive to individual needs, which promote the integral development of students with ASD.

Key words: Educational inclusion, autism spectrum disorder, information and communication technologies.

Resumen. La inclusión educativa de estudiantes con trastorno del espectro autista (TEA) en la educación superior plantea desafíos y oportunidades, especialmente en los programas de Tecnologías de la Información y la Comunicación (TIC), caracterizados por su alta demanda cognitiva y tecnológica. Este artículo propone una estrategia metodológica orientada al acompañamiento pedagógico de estudiantes con TEA funcional en carreras TIC, con el objetivo de promover el aprendizaje significativo, la participación activa y la permanencia académica. La propuesta se basa en una revisión teórica, el análisis de experiencias universitarias reales y la integración de las mejores prácticas internacionales. La estrategia aborda las dimensiones curricular, tecnológica, social y emocional de manera integral, buscando garantizar una educación superior más inclusiva y equitativa. Este enfoque busca establecer bases sólidas para el diseño de apoyo específico para estudiantes con trastornos del neurodesarrollo, favoreciendo su éxito académico. Asimismo, destaca el papel de las TIC como herramientas clave para potenciar la motivación, el compromiso y la autonomía, mediante la creación de entornos de aprendizaje adaptativos y sensibles a las necesidades individuales, que promueven el desarrollo integral de los estudiantes con TEA.

Palabras Clave: Inclusión educativa, trastorno del espectro autista, tecnologías de la información y la comunicación.

1 Introduction

Education at the university level represents a great challenge especially in careers related to Information and Communication Technologies (ICT), where advanced technical competencies and specific cognitive skills are required. Students with autism spectrum disorder (ASD) face particular barriers at this educational level due to the academic and social demands of these careers. Therefore, it is critical that learning environments are not only accessible, but also tailored to their individual needs to ensure their education. These barriers include difficulties in social communication, cognitive rigidity, sensory overload and a preference for structured and predictable environments [1].

At the same time, ICT careers offer an environment with the potential to support inclusion by enabling more visual, autonomous and structured learning modalities, which can align with the cognitive strengths of many students with ASD, such as logical-sequential thinking and attention to detail.

This article presents the design of a methodological strategy that integrates approaches such as the TEACCH model, Universal Design for Learning (UDL), Project Based Learning (PBL) and the use of ICT, to promote inclusive and equitable education at the university level. This proposal responds to the need to transform teaching-learning environments into accessible, personalized spaces focused on neurocognitive diversity.

2 Theoretical framework

The World Health Organization defines autism spectrum disorder (ASD) as a neurodevelopmental condition characterized by persistent difficulties in social communication and restricted and repetitive patterns of behavior [1].

Other features associated with this disorder are deficits in social-emotional reciprocity, communicative behaviors, motor stereotypies, insistence on monotony and very restricted and fixed interests. In addition, individuals may exhibit hyperreactivity to sensory stimuli such as apparent indifference to pain or temperature, adverse response to sounds or textures and a visual fascination with lights or movement [2].

Because of the characteristics of the condition, the difficulties for college students are considerable upon entry at this level. Many may be victims of bullying, develop inferiority complexes and often feelings of frustration that together can lead to other disorders in the form of crises [3].

It is estimated that approximately 1% of the world's population has ASD; however, the proportion of students with autism at the university level is considerably lower. A study conducted in the United Kingdom indicates that about 0.4% of university students identify as having autism, evidencing an underrepresentation relative to the overall prevalence [4].

This discrepancy may be due to a variety of barriers, including challenging transition from secondary education, lack of specific support at universities, stigmatization, or no formal recognition of the diagnosis. At the university level, students with ASD require strategies that not only consider their cognitive performance, but also their emotional well-being, social integration and autonomy. To address these needs, the proposed methodological strategy is based on three complementary approaches:

- TEACCH model (Treatment and Education of Autistic and Communication related handicapped Children): is a structured educational approach focused on visual organization, individualization of learning and promotion of autonomy. Although the characteristics of people with ASD are different from each other, they also present some similarities, so TEACCH seeks to provide interventions that help balance these characteristics with the norms and culture of the social environment [5]. Although it was initially designed for children, it has been shown to be effective in university settings by adapting its principles to higher education.
- Universal Design for Learning (UDL): is a comprehensive framework that seeks to shape the design of learning environments so that they are accessible to all learners. Its overall goal is to foster autonomy for the learning process by planning and designing for an optimal experience that fits their specific needs. It focuses on transforming the learning environment rather than transforming learners and emphasizes intentional design to minimize barriers and provide meaningful learning experiences [6].
- Project Based Learning (PBL): aims to improve students' academic performance and skills. This method has been adopted in various fields of education. PBL not only seeks to improve academic performance and maintain students' attention and engagement, but also to develop technical and non-technical skills that are key to professional success [7].

3 Methodology design

Education at the university level represents a great challenge especially in ICT-related careers, where advanced technical competencies and specific cognitive skills are required. Students with ASD face particular barriers at this educational level due to the academic demands of the field.

The proposal of this methodology not only aims to address the barriers to learning and participation faced by students, but also to enhance their capabilities by considering their cognitive processes, interests and learning rhythms through a flexible, accessible and structured pedagogical environment. Figure 1 shows a clear and systematized path of action divided into phases, which include instruments and procedures that allow addressing the individual needs of each student.

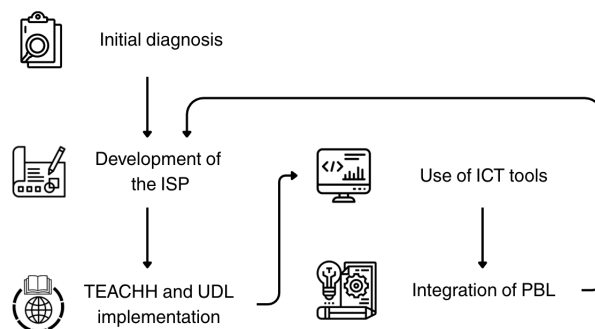


Figure 1. Methodology phases.

3.1 Initial diagnosis

This stage is the starting point for understanding the student's profile and planning personalized interventions. It involves gathering relevant information on cognitive, emotional, sensory, communicative and social aspects. Since these are university students, many of them already have a formal initial diagnosis of ASD, so the process should focus on:

- Update relevant information on their profile and evolution.
- Identify current barriers in the academic and social context.
- Recognize strengths, personal resources and compensatory strategies previously developed.
- Establish specific needs for reasonable support and curricular adjustments.

3.1.1 Instruments

In order to carry out a meaningful evaluation and collect information in a multidimensional manner, we propose the use of validated instruments adapted to the university context, in order to provide a comprehensive view of the student's profile:

- **Strengths and Difficulties Questionnaire (SDQ):** is a questionnaire for the detection of abnormal behaviors, which consists of 25 items distributed in five subscales, which considers emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems and prosocial behavior. This is measured on a Likert scale to obtain the corresponding score [8]. As shown in Figure 2, the interpretation is classified into ranges, where a high score may indicate the need for further evaluation.

Self-completed SDQ			
Total difficulties score	0-15	16-19	20-40
Emotional problems score	0-5	6	7-10
Conduct problems score	0-3	4	5-10
Hyperactivity score	0-5	6	7-10
Peer problems score	0-3	4-5	6-10
Prosocial score	6-10	5	0-4
Impact score	0	1	2-10

Figure 2. SDQ Scale [9].

- **Honey-Alonso Questionnaire of Learning Styles (CHAEA):** this is an instrument widely used at the university level and is useful to identify and establish the level of preference of a student's learning style, which allows improving their preferred styles and enhancing their less developed styles [10]. It consists of 80 items divided into four groups of 20 each, where participants respond by indicating their degree of agreement or disagreement. In this way, a more complete understanding of their learning strategy is achieved, which will allow teachers to adapt their methods to meet the diversity of styles present in the classroom. Figure 3 shows a graph with the 4 learning styles: active, pragmatic, reflective and theoretical.

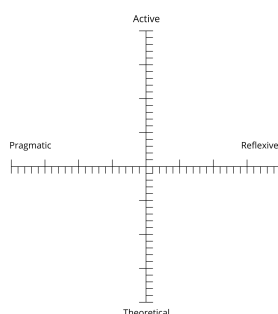


Figure 3. Graph with learning styles.

In addition to standardized instruments, semi-structured interviews are a key tool to complement the understanding of the student's profile. Through them, it is possible to access subjective and contextual information that is not always reflected in questionnaires, allowing to identify perceptions, previous experiences and dynamics that influence their educational process. In the interviews it is suggested to address:

- With the student: perception of his/her abilities, challenges in academic and social life, previous experience with support or curricular adaptations, interests, motivations and coping strategies.
- With family members or guardians (only if authorized by the student): medical and diagnostic history, school transitions, aspects that have facilitated or hindered adaptation in other contexts.
- With teaching staff: previous experiences with the student, barriers observed, responses to different situations or methodologies and level of participation in school activities.

Table 1 shows the activities and those responsible for the application of the instruments in order to obtain the expected products.

Table 1. Activities for the application of instruments

Activity	Content	Responsible
Background check	Data collection on an institutional basis	Psychoeducational support staff
SDQ application	SDQ questionnaire	Psychologist or academic staff
CHAEA application	CHAEA questionnaire	Academic staff
Interviews	Interviews elaborated for the university context	Psychologist and academic staff

3.2 Individualized Support Plan (ISP)

From the previous assessment, the Individualized Support Plan (ISP) is constructed, which is a process of development, implementation and evaluation of individual goals and objectives related to personal outcomes in terms of the amount of support and the degree of adaptive behavior [11].

This plan should include a summary of the individual profile that captures the most relevant information derived from the initial diagnosis. It should also specify the support strategies needed to achieve the objectives, which may include methodological adaptations such as the use of visual materials, adaptations to assessments, integration of technologies, among others. Table 2 shows an example of the contents of the ISP.

Table 2. Contents of the ISP

Section	Content
General data	Name, university career, semester, diagnosis (when applicable and with full consent).
Individual profile summary	Predominant learning style, cognitive and technical strengths, difficulties (academic, sensory, social), coping strategies.
Individual objectives	Academic: specific goals related to the subjects of the career. Social: integration in teams, communication and interaction with group mates. Autonomy: use of technologies for their own organization, as well as sensory self-regulation.
Support strategies	Methodological and evaluative adaptations, technologies to be used.
Indicators and monitoring	Rubrics, logs, progress logs and self-assessment tools.

Review dates	Planning of periodic reviews: at the beginning, middle and end of the semester, adjusted to the academic calendar.
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The ISP should have a periodic review together with the student and a teacher or a group of teachers, which will allow adjustments to be made according to academic progress, changes in needs or teacher feedback, so it is advisable to use rubrics, logs and self-evaluations.

3.3 Adapted pedagogical implementation

At this stage, the ISP ceases to be a static document and is transformed into concrete actions within the classroom and learning spaces. It is based on the TEACCH model and the UDL, following some pedagogical principles:

- TEACCH: visual organization of the space: clearly differentiate areas, such as the blackboard or projector, teacher's desk and students' places. Structured routines: schedules indicating due dates, start and end dates of activities, class schedules, among others. Breakdown of tasks into steps: e.g. "Step 1: identify a variable, Step 2: write in pseudocode, Step 3: test an algorithm".
- UDL: multiple forms of representation: videos with subtitles, printed or digital infographics, audio materials, among others. Multiple forms of expression: digital portfolios to upload evidence, mind maps with visual tools, short oral presentations with visual aids. Multiple forms of involvement: relate technical content with personal interests (e.g., developing short video games), use open questions in virtual forums to promote reflection, offer optional challenges of gradual complexity, use gamification techniques.

3.4 Use of ICT

This phase focuses on providing students with tools that reinforce their learning, autonomy and organization, while facilitating the teaching work.

One of these tools is Trello, a visual work management tool that allows planning, managing and organizing tasks through visual lists and cards that can be labeled, scheduled and divided into subtasks, in a collaborative, productive and organized way [12]. It can be used as follows:

- Separate boards by subject, where each card represents an activity or project.
- Checklists on each card, with simple steps (e.g., "read a chapter", "solve an exercise", "submit an assignment").
- Integrated calendar to display due dates with alerts.

On the other hand, Notion is a more robust tool that combines notes, tasks, calendars and multimedia in a single highly customizable environment, allowing to organize and plan tasks and projects according to the needs [13]. In the university context, Notion can be used for:

- Agenda templates with sections for academic activities, quick notes or reminders.
- Resource database with links to videos, notes, code samples or documentation.
- Progress tracking modules where students record daily achievements and brief reflections on their academic progress.

In the case of technical subjects such as programming, visual and guided development environments can be used to facilitate the understanding of computational logic by minimizing the syntactic load and offering graphical support.

One of the most widely used applications is Scratch, a block-based programming environment that allows building algorithms by joining visual pieces to create digital stories, games and animations, promoting computational thinking and problem solving in a personal and collaborative way [14]. With this tool, the student can:

- Begin to focus on sequential reasoning without the need to memorize textual syntax.
- Make initial projects focused on block logic through animations or small games.
- Use preconfigured templates to avoid spending too much time on preconfigurations and concentrate on logic.

The Scratch interface simultaneously displays the scenario where the program runs, the blocks and the scripting area, providing a predictable and structured space. In addition, responding to events such as clicking,

typing or displaying messages reinforces the “cause-effect” relationship and encourages controlled experimentation, reducing the anxiety that could be generated by unexpected errors.

Another tool that can complement the approach to programming is PSeInt, a tool that allows focusing on the fundamental concepts of algorithms through pseudocode [15]. Among the main features of this software are:

- Write instructions in pseudocode and execute the algorithms step by step, visualizing, for example, the value of variables.
- Use pseudocode templates with basic conditional and loop structures already defined for the student to complete specific parts.
- Display contextualized warning messages with annotations indicating syntax errors or uninitialized variables, which helps to reinforce self-regulation in code debugging.

3.5 Incorporation of PBL

The PBL is organized in four short and structured phases, so that the student has clarity at all times about what is expected of him and how to progressively advance:

- Problem statement and planning: the formulation of the problem should be presented visually, through an outline that includes elements such as the objective, the steps to be followed and the final product. The timeline should appear as a simple timeline, without extensive text and with well-defined roles if it is a collaborative project.
- Development: activities should be divided into concrete and sequential steps. The teacher's indications should be available in writing, avoiding relying exclusively on verbal instructions, which may be difficult for some students to process.
- Testing: in the usability evaluation phase, it is recommended to use short forms with closed response items (e.g., "yes/no" or scales from 1 to 3). Necessary corrections should be marked visually, using colored labels on the work board, allowing the student to quickly identify the required adjustments.
- Final presentation: it is advisable to make the presentation format more flexible. A good practice is to prepare a short video showing the prototype in operation and explaining its logic. This can be complemented with diagrams illustrating the phases or steps followed during the development of the project.

3.6 Strengthening and sustainability of the methodological strategy

The effectiveness of a methodological strategy for the inclusion of students depends not only on the pedagogical design, but also on its comprehensive implementation, institutional support and capacity for continuous improvement, so the following complementary actions are proposed to strengthen and ensure the sustainability of this proposal:

- Teacher training and awareness: it is essential to incorporate continuous training processes for teachers, focused on the understanding of ASD, UDL and the use of technologies.
- Active student participation: the strategy recognizes the student with ASD as the protagonist of his or her educational process. Their active participation is promoted in the construction of the ISP, in the selection of tools according to their needs and in the definition of topics or approaches in academic projects according to their learning style.
- Evaluation and continuous improvement: to ensure the relevance of interventions, a continuous evaluation system should be established that includes instruments such as inclusive rubrics, monitoring logs, reflective interviews and periodic reviews of the ISP.
- Transition to the professional environment: given that ICT programs have a practical and professionalizing orientation, it is advisable to include activities that prepare students for their insertion into the labor market. This may include interview simulations, supervised professional internships and alliances with entities that are sensitive to diversity and labor inclusion.

These complementary actions ensure that the methodological proposal not only responds to the academic demands of the present, but also provides tools for students autonomy and professional development.

4 Conclusions and future work

The proposed methodological strategy, which integrates TEACCH, UDL and PBL has proven to be coherent and effective by articulating from the initial diagnosis to the final presentation of the project, offering multiple access paths and clear structures that favor the autonomy and motivation of students with ASD; in addition, the link between the ISP and each phase of the project, together with a continuous evaluation system, has made timely adjustments possible and has laid the groundwork for its institutional sustainability.

Although its pilot scope was limited to a software development course and the reliance on certain digital platforms may require additional teacher training, these first experiences pave the way for validating the methodology in other subjects.

In parallel, longitudinal studies are proposed to follow several promotions of students with ASD from their entry into the labor market, measuring not only indicators of academic performance and time to graduation, but also variables of autonomy, socioemotional skills and professional success in the medium and long term. On the other hand, the exploration of immersive technologies will make it possible to evaluate their capacity to offer immediate feedback and adjust activities according to the level of cognitive load and individual learning style. In the field of artificial intelligence, we plan to develop prototypes of recommendation systems that suggest personalized resources, step-by-step guides or alternative presentation formats based on the interaction history of each learner.

Finally, with the aim of consolidating a global community of practice, an open repository will be built in the cloud to house methodological guides, adaptive templates, documented case studies and discussion forums, facilitating the exchange of experiences and the replication of the model in different institutional contexts.

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Coping strategies effectivity in students with language disorder, role stress in students Efectividad de las estrategias de afrontamiento en estudiantes con trastorno del lenguaje, estrés de rol en estudiantes

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Summary. This is an analysis of main coping strategies for students with any language disorder in stress environment like school, the study has included regular students in order to contrast findings between two groups of students. Firstly, we offer a detailed description of main sources of stress (family, school, schoolmates) and their relationships, the instrument used to collect information about stress was a brief version of the Adolescent Stress Questionnaire (ASQ), ASQ was applied to 6 dyslexics persons or with history of disorder language and 9 regular students, a question has been added to ASQ: "how long have you been in stress?" in order to measure the chronic stress. Higher correlations were between chronic and no adaptive strategies, following of family stress with school stress, literature relating to stress point out that family stress and school stress both reach higher levels of stress in adolescence, another findings is the high incidence of chronic stress which make it a variable which worth a deep research, there are many studies about stress at work and burnout, actually this study show that scholar burnout may occur a lot earlier and a lot worse that everyone though. Discussion. The literature asserts that both social changes and rising expectations has caused that stress level in younger groups has increased, and about groups of people with any disorder language this increment is almost negative double, there is the problem of rise expectations and higher standards and how can cause school dropouts and antisocial behavior, which increases the importance of remedial interventions and special cases management like language disorder.

Keywords: Coping, Remedial Intervention, Stress.

Resumen. Este es un análisis de las principales estrategias de afrontamiento para estudiantes con cualquier trastorno del lenguaje en un entorno estresante como la escuela. El estudio incluyó a estudiantes regulares para contrastar los hallazgos entre dos grupos de estudiantes. En primer lugar, ofrecemos una descripción detallada de las principales fuentes de estrés (familia, escuela, compañeros) y sus relaciones. El instrumento utilizado para recopilar información sobre el estrés fue una versión abreviada del Cuestionario de Estrés Adolescente (ASQ). El ASQ se aplicó a 6 personas disléxicas o con antecedentes de trastorno del lenguaje y a 9 estudiantes regulares. Se añadió al ASQ la pregunta "¿Cuánto tiempo llevas estresado?" para medir el estrés crónico. Se observaron correlaciones más altas entre estrategias crónicas y estrategias no adaptativas, siguiendo el ejemplo del estrés familiar con el estrés escolar. La literatura sobre estrés señala que tanto el estrés familiar como el escolar alcanzan niveles más altos en la adolescencia. Otro hallazgo es la alta incidencia del estrés crónico, lo que lo convierte en una variable que merece una investigación profunda. Existen numerosos estudios sobre el estrés laboral y el síndrome de burnout; de hecho, este estudio muestra que el síndrome de burnout académico puede ocurrir mucho antes y con una gravedad mucho mayor de lo que se pensaba. Discusión. La literatura afirma que tanto los cambios sociales como las crecientes expectativas han provocado que el nivel de estrés en los grupos más jóvenes haya aumentado, y en los grupos de personas con algún trastorno del lenguaje este incremento es casi el doble negativo, existe el problema del aumento de las expectativas y los estándares más altos y cómo pueden causar deserción escolar y comportamiento antisocial, lo que aumenta la importancia de las intervenciones correctivas y el manejo de casos especiales como el trastorno del lenguaje.

Palabras Clave: Afrontamiento, intervención correctiva, estrés.

1 Introduction

This study reports the measuring of coping strategies in an environment perceived as stressing and tied with any Language Disorder (LD), in order to classified in effectivity terms to help students with LD in their stress management and enhance academic performance.

That is to say, this study sizes the effectivity of coping strategies in an environment with stress caused by LD and school.

This work classified effectivity factors in a coping strategies context, and detail how coping strategies work better in many contexts, personalities and age ranges, in order to prepare them in a configuration where we can apply statistics methods and find the higher correlations between variables.

Main studies about coping strategies effectivity are closely linked with cross studies about chronic diseases, school stress, traumatic events, traumatic environment and different conditions related with reading comprehension and reading disabilities.

This work integrates terms like coping strategies, effectivity of coping strategies, stress, causes of stress, control over stress, role of stress in adolescents, effectivity levels of coping strategies in school context.

Coping strategies literature has pointed just two categories of coping strategies [1] [2], some authors pointed out a third category but it seems more a sub-division of coping strategies no adaptive (which use more the emotion), and they said that there's few studies about profiles as well.

In general, specialized research of coping strategies establishes two categories only, the most suitable solution is to promote the better coping strategy and avoid the less effective strategy, but precisely there is the need to be more specific about the interaction of patterns and how decisions are made, besides clarify the barriers that hampers the decision process, like stress and DL.

The foregoing has the problem of be very general and we need to personalize the coping strategies, so, finally, we propose profiles and sub-profiles that integrate the interaction between DL and stress, profiles could be useful for design and implementation of remedial intervention in educative contexts, and as a base for educative politics that promote scholar inclusion.

One common limitation in studies in language disorder are the small samples and the difficult to generalize the findings.

1.1 Coping and language disorder

The following will explain background of coping and language disorder and their relationship in a scholar environment.

First notion of coping was known as an unconscious defensive answer to face stressing stimulus, and was presented by Freud [3], later was introduced by Lazarus as a conscious answer, finally Bowlby y Salomon [5] established in which stage the coping start to develop.

Coping represent a constant change either at cognitive and behavior context to manage internal and external demands considered as large load or exceeds the resources of the person [2].

About the process of generating indicators of coping strategies effectivity has barriers like lack of conceptual clarity because of diversity of concepts about coping, this impact negatively in the formulation of conclusions and metrics related with effectivity of coping strategies [6].

About reading disorders there is two kinds: decoding difficulties (dyslexia) and text comprehension difficulties [7] [8], these type of disorders have different cause and require different treatment, for this study both cases will be under language disorder category.

The reading and comprehension standard is more known because the collective perception had defined what is acceptable, desirable or ideal; Harter [9] show the relationship between standard in educative context and coping strategies and DL with the next coping strategies: 1) work hard to achieve these standards 2) ask help from people we trusted like teachers, parents. 3) reduce the standard 4) avoid compare ourselves with people in same situation like schoolmates.

From previous strategies the number 1 and 2 are considered more positive (adaptive strategy), these strategies commonly create a positive auto-dialogue, create a good adaption ad well, and end with a sense of self protection, growth and help our self.

Strategies 3 and 4 are considered less positive and perceived like an incorrect adaptation, generally people that use these strategies have the experience or awareness that not is easy for them to achieve the school standards and must strive hard, at this point, when they did not make it, start to use many actions to defend self-esteem, even try to reduce the importance of learning.

Some characteristics of people that use adaptive strategy (positive coping strategies) are: very good at fitting to stressing situations, good at integrating positive experiences related to the stress in their live – a kind of reuse of good experiences-, mostly have 5 key characteristics: social competence, good problem solving, confidence, independence, achievement oriented. [10]

Moreover, are sensitive, empathetic, deep understanding of their environment and the people, are driven by inner motivation and autonomous thoughts [11].

The description of a person that use mostly coping strategies no adaptive –or emotion based- is: most commonly does not solve the present problem, avoid, procrastinate in work or school, could not have emotional connection with the environment and could easily get in illegal substance consumption, some of previous activities could be useful to keep emotional balance or emotional regulation.

About the collection of coping strategies effectivity metrics with people with LD, preliminary analysis with regard of interactions between elements was conducted and show that mostly of coping strategies are very close

to circumstances, to live phases, to experience with coping strategies, basically this behavior is the result of mutual influence of each element, from this interactions of mutual influence a theory was born and is known as transactional theory [2].

In conclusion from the above, the accumulation of achievements or mistakes strengthens or reduces the self-confidence and is a factor of resilience development, is a strong influence in the best selection of a coping strategy as well.

1.2 Causes of stress and control over causes of stress

Next step is the definition of stress, stress causes, the origin, nature and impact in the selection process of coping strategies in students with LD.

Stress is a response of the body to any demand, whether it is caused by, or results in, pleasant or unpleasant conditions [12], the responses to stress are known as coping or facing, in general there are two coping families: avoid coping (no adaptive or emotional) that is more used to face family and peers, and approach coping (adaptive) more commonly used for tasks, school and problems [13].

The three identified main causes of stress in adolescence are: family, school, schoolmates [14] [15] [16], more commonly people with stress perceive the school as a more controllable cause of stress than family and schoolmates [17] [13].

Many authors establish that the greater cause of stress are the interpersonal relationships [18] [19] [16].

As regards of stress development, stress behavior patterns are formed from childhood [19], nowadays children are exposed to many situations where have to make many decisions [20], consequently children stress have reached pandemic proportions [21], we can add the rising expectations and social changes that increase stress as well [19] [22].

Daily stress that accumulates could increase the risk of having or developing any psychological problem [23] [24] [25].

Currently stress is accepted in society and includes some modes to relieve it, commonly is more accepted for adults but not for children, for children these practices are punished, some forms of discharge are: anger, frustration; even parents and teachers show anger, stay away from other people to calm, take medication or retracting, this situation seems that only adults have big pressures and need to relieve.

The last characterization of the current state of stress is: having DL multiply the stress level, is very common that DL come with another disability and that add another level of stress, finally these situation cause confusions that lead to a bad selection of coping strategy, choosing negative coping strategies instead of positive coping strategies.

1.3 Effectivity levels coping strategies, factors of stress in adolescence

Experts conclude that coping strategies are hard to measure because depend of many contextual and temporary factors [26], besides these factors have highly dynamic behavior.

In this work effectivity has several meanings, firstly, high grades in a scholar context, also could be pressure and exigency for teachers and students, in general is similar to a standard or a sort of quantitative level.

In a broad view the metrics and standards fit better with regular populations.

In the current work the effectivity of coping strategies has the perspective from students with DL and stress, for most for them standard means a source of stress and in this context effectivity represent the selection of the best strategy for a concrete situation.

Some of the coping strategies can be viewed as a contradictory action because does not try to reach a standard, but as some authors said that is very common apply a wide variety of coping strategies including avoid and do nothing.

There is a lack of knowledge about the latter situation, is very similar to the dyslexia case, the more profound the research about dyslexia, the findings is more complicated and hard to delimit it.

Actually the dyslexia complexity reaches such a degree that some authors start to point out that dyslexia is more close to be considered as an alternative of information process that evolved for hundreds of years than a language disorder [27].

Adding to the issue of individuals with DL coping strategies effectivity metrics: the effectivity of coping strategies is being in a position where in every moment and context apply the best coping strategy for them.

The enhancement of coping strategy selection process consists in: not giving too much weight to quantitative result but wellbeing in their particular perspective, the benefits could be: confusion reduction, the correct

assessment of their resources, increase assertiveness, increase acceptance feeling, reduce stress, in summary, an overall well-being and better quality of life.

The best results and a better fit to any situation are obtained when the people use a coping strategy approached to solve problems and when the source of stress is perceived as controllable.

People tends to use coping strategies no adaptive (emotion) when the source of stress is perceived as uncontrollable, commonly interpersonal relationships like family and schoolmates, the control over stress sources is the degree that the demanding situation can be prevented or eliminated by their skills, resources or actions of individual [28].

There's segments of population that belongs simultaneously to the two coping strategies categories, –as a sample of social diversity–, the most remarkable factor to belongs to the first or second category is the receptiveness of their family or their school or schoolmates.

1.4 Coping strategies, findings, pairs individual-strategies accepted

Research about the use of coping strategies from adolescent in age range of 13-17 years old, show that mostly use coping strategies (adaptive), and adolescent in age range of 18-20 use no adaptive coping strategies, other researcher reports contrary findings and others find no differences.

As other objects of study the findings depend on the kind of collect data and other aspects of the research methodology.

In a general way the coping strategies no adaptive (emotion approached) include relaxation, release affective or emotional regulation, this coping strategy is more used by girls than boys [13] [29] [30].

The coping strategy no adaptive (emotion) used as emotional release and intake of substances or drugs consumption is more commonly in women [31] [32].

The statement that women use more coping strategies no adaptive was perceived like a lack of assertiveness [32].

In general women use same kind of coping strategy that women in mental treatment what suggest that women that use this kind of strategy tends to develop mental disorder [33].

There are better results in terms of time with coping adaptive, and worst results with coping no adaptive [34], that is, more close to the quantitative view.

According to west values and culture, coping adaptive has more worth than coping no adaptive [35] [36] [37] [38].

Notorious behavior in the use of coping strategies is to use many coping strategies in many levels [39].

There is not an only better effective coping strategy, effectivity lies more in flexibility and the use of wide variety of strategies in each situation [40].

2 Methodology

The sample was of 15 people, 6 dyslexic people or with any perceived language disorder and 9 regulars people, all of them are enrolled in the Aguascalientes Autonomous University, in Ingeniería en Computación Inteligente program, all single, 10 men and 5 women.

To manage the information of participants we follow the ethical regulations of Aguascalientes Autonomous University, and a verbal consent with the participants.

The collecting information methods were survey and direct interview, and the methodology approach was qualitative, the instrument for collect information was a modified reduced version of Adolescent Stress Questionnaire (ASQ), the original instrument (ASQ) has 10 dimensions because of the appropriateness of the information, it is reliable and high predictive power for depression, anxiety y low self-stem, we add the dimension of duration of stress to get chronic stress variable.

For every dimension two questions were added in order to complement the dimension of time -chronic stress-, were just two questions in order to maintain their attention and clarity in their answers.

1. Stress caused by family
2. Stress caused by scholar performance
3. Stress caused by interaction with schoolmates
4. Stress caused by uncertainty of the future
5. Stress duration
6. Coping strategy used

Questions of dimension 6- Coping strategy used, try to place the respondent in a scholar context where was in exams in a subject which have had problems to pass, some instructions and help were given to recreate the context to use a coping strategy, all this was to clarify what kind of strategy was used..

3 Results

The instruments reliability was determined by Cronbach alpha statistics test, for this study the Cronbach index was 0.69.

A matrix table with 6-dimension report is presented, the higher correlations of dimensions was 5- Stress duration and 6- Coping strategy used with a value of 0.790.

The second higher correlation is 2- Stress caused by school with a value of 0.732.

Next table show correlation matrix.

Table 1. Correlation matrix table.

	Stress by Family	Stress by School	Stress by Schoolmates	Uncertainty by Future	Stress Duration	Coping Strategy Selection
Stress by Family	1.000	0.732	0.412	0.295	0.518	0.602
Stress by School	0.732	1.000	0.398	0.201	0.450	0.557
Stress by Schoolmates	0.412	0.398	1.000	0.309	0.323	0.367
Uncertainty	0.295	0.201	0.309	1.000	0.502	0.533
Stress Duration	0.518	0.450	0.323	0.502	1.000	0.790
Coping Strategy Selection	0.602	0.557	0.367	0.533	0.790	1.000

Table 1. Correlation matrix between dimensions of Adolescent Stress Questionnaire (ASQ) instrument.

Most of findings are very similar with those from the specialized literature, specifically in the dimensions of stress in school and family stress, both are considered the most influential cause of stress for young people.

About the higher correlation that is stress duration –chronic stress- and bad coping strategy selection, for long time chronic stress and the job have been very close, but now start to be considered LD as a kind of burnout and a candidate to be a similar treatment.

4 Conclusions and future work

Beside of the fact of school and family as the main factor of stress in young people, the correlational analysis shows a consistent relationship between chronic stress and incorrect selection of coping strategy in a context where the best fit seem to be the adaptive coping strategy.

The higher correlation shows that in certain way is very similar with point 1.2 causes of stress, where the stress at child level has reached high level, in a first analysis this fact is consistent with actual social changes for childhood, where there is a high exposition to information and a context where is more common made important decision.

The people with the condition of disorder language has a higher probability of increase of stress.

In this field of research where the goal is achieving better scholar environments in order to enhance the academic performance and inclusion, come another factor that seems to be created from better technology infrastructure and definitively increase the stress.

Some of the consequences of chronic stress means a path to repeated episodes of mental health deterioration (depression, etc.), is a progressive condition where the capacity to make causal inferences is hampered therefore come an increase of bad decisions that deteriorate the life of individuals.

We suggest that educative institutions take in consideration the stress factor in order to adequate the educative planning.

Future work will be chronic stress and interrelationships in a educative context, in order to design and implement remedial interventions.

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Profiles of coping strategies used by dyslexic student at university level Perfiles de estrategias de afrontamiento utilizadas por estudiantes disléxicos a nivel universitario

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Summary. This work is about an analysis of coping strategies at school from dyslexic students, coping strategies are answer mechanism that people use to manage stress and demanding situations, firstly demanding situations are detailed and categorized in order to extract profiles which will be used to enhance the design and implementation of remedial interventions at school. We did work with a representative set of 20 people, 7 dyslexic students and 13 regular students, in order to collect information, we use a modified set of questions of Singer's instrument which was used in academic failure research, we extend an another dimension of data in the cases of questions with answers that becomes dependent, in this case a new question was asked: "describe this dependence", this information become relevant in the extract profiles activity. Findings: this study confirm the two-way value (positive and negative) of main sources of demanding situations to coping, which are family, school and schoolmates. Conclusion: it is very clear the wide range of coping strategies, in terms of effectivity not one coping strategy must be rejected by dyslexic people, in broad terms dyslexic people tends to make bad decisions in coping strategies selecting and always will depends on support of another people, dyslexic people with the support of some people could reach or be close to traditional school standards, every positive support of people creates a kind of virtuous circle in dyslexic people, so the need to get family and schoolmate aware of the value of their interactions with dyslexic people, finally is a high priority, a common limitation in this kind of studies is the size of sample, in general is very short and make it hard to generalize the findings beside of the variability of coping strategies in every individual disorder.

Keywords: Coping strategies, Dyslexia, Remedial interventions.

Resumen. Este trabajo trata sobre un análisis de las estrategias de afrontamiento en la escuela de estudiantes disléxicos, las estrategias de afrontamiento son mecanismos de respuesta que las personas utilizan para manejar el estrés y las situaciones exigentes, en primer lugar, las situaciones exigentes se detallan y categorizan para extraer perfiles que se utilizarán para mejorar el diseño e implementación de intervenciones correctivas en la escuela. Trabajamos con un conjunto representativo de 20 personas, 7 estudiantes disléxicos y 13 estudiantes regulares, para recolectar información, utilizamos un conjunto modificado de preguntas del instrumento de Singer que se utilizó en la investigación del fracaso académico, extendimos otra dimensión de datos en los casos de preguntas con respuestas que se vuelven dependientes, en este caso se hizo una nueva pregunta: "describe esta dependencia", esta información se vuelve relevante en la actividad de extracción de perfiles. Hallazgos: este estudio confirma el valor bidireccional (positivo y negativo) de las principales fuentes de situaciones exigentes para el afrontamiento, que son la familia, la escuela y los compañeros de escuela. Conclusión: es muy claro el amplio rango de estrategias de afrontamiento, en términos de efectividad ninguna estrategia de afrontamiento debe ser rechazada por las personas disléxicas, en términos generales las personas disléxicas tienden a tomar malas decisiones en la selección de estrategias de afrontamiento y siempre dependerán del apoyo de otras personas, las personas disléxicas con el apoyo de algunas personas podrían alcanzar o estar cerca de los estándares escolares tradicionales, cada apoyo positivo de las personas crea una especie de círculo virtuoso en las personas disléxicas, por lo que la necesidad de que la familia y los compañeros de escuela sean conscientes del valor de sus interacciones con las personas disléxicas, finalmente es una alta prioridad, una limitación común en este tipo de estudios es el tamaño de la muestra, en general es muy corta y dificulta la generalización de los hallazgos además de la variabilidad de las estrategias de afrontamiento en cada trastorno individual.

Palabras Clave: Estrategias de afrontamiento, dislexia, intervenciones correctivas.

1 Introduction

We present a coping strategy analysis and how dyslexic people used them at the school, in this way we propose a set of profiles and stressing cause situations in order to obtain a better understanding of this patterns, and design and implement remedial interventions or any action that support inclusion and achievement of academic goals.

The outlook of very few coping strategies categories (mostly 2 categories) make needed to find a differentiation and more options of strategy selection, the methodological procedure was to add dimensions to the variables in order to find sub-patterns.

This study was developed in the Universidad Autónoma de Aguascalientes, and the report is an analysis of contrasting the findings with regular students, dyslexic students and findings of related literature.

The present study findings are a set of patterns of responses and coping strategies in order to prevent, decrease or respond to demanding situations [1].

There are many situations that interact in coping strategy selection by dyslexic students or students with language disorder and regular students, these situations need to be clarified, that is, how these elements influence the decision process.

The sample has the next characteristics: a range of age between 12 – 21 years old, some known pre-conditions are: main causes of stress are: pressure by expectative, interaction with schoolmates, teachers and family, family economy, uncertainty [2], coping strategies patterns are developed in the childhood [3],

Actually people stress level has been increased by social changes and expectative rise, mostly in early stage of childhood [14], that is why chronic stress is considered as factor in the coping strategy decision process.

There are many limitations in the process of refining a profile of coping strategy selection: a) is hard to define and conceptualize the coping term b) the excessive amount of measurement scales and variety of perspectives c) the coping strategy categories with just only 2 categories leads to exaggerated overlap between categories that does not help to define profiles.

The extracting of profiles is useful in order to enhance the understanding of individual responses to stressing situations and as a guide in the better selection of coping strategies and adapt remedial interventions to increase academic performance and improve the welfare.

1.1 Coping facing challenges, behavior and resources patterns

First studies about coping come from the roots of psychoanalysis and how people hand the internal conflicts, since Sigmund Freud in many works [5].

Coping is a pattern that include a variety of activities to face stress and difficulties, involve actions in the sphere of emotion ad task completion, coping is a factor in personal growth and resilience as well.

Coping is a set of behaviors used to prevent, decrease or respond to face demanding or stressing situations [1].

Coping is a way to respond to stress and challenges, is very common that individuals use a wide range of coping strategies [6].

There are many resources related with coping and each one has different weight, the following are some examples: confidence, situational control, emotional control, social support (family, schoolmates, teachers), structure (management and organization like time and energy), development and monitoring of plans, physical health, wellbeing, energy, auto-driven, self-direction, assertiveness [7], even these resource has its own measure instrument Coping Resources Inventory for Stress (CRIS) [8].

1.2 Coping strategies, elements and configurations

There are many elements that influence the coping development: demanding situations and emotions –coping help to regulate negative emotions and to face stress in an effective way-; mental health –coping can reduce anxiety and depression); Personality: personal traits like resilience and self-efficacy influence the kind of strategies that an individual use, depression is included and is considered as a mood disorder with symptoms like enduring sadness and a lack of motivation in any activity [9].

There are other elements: social support: help and support of family, friends and significant persons, facilitate a better coping strategy selection to face difficulties; experiences and accumulation of experiences positives or negatives model personality and the way to face new challenges to increase wellbeing, are learning process and growth for lifetime.

These components can become articulated on many ways and could explain many behaviors related with coping, from children [12] [13], the factors that can have favorable and unfavorable effects in the tuning the process of coping strategies selection are the same: family, school and schoolmates.

The coping strategies selection has a level of variability by gender and age, besides of previous ones.

The kind of strategies selected could have positive or negative influence in self-stem and depression [14].

1.3 Coping strategies, a chronological view

For 50 years the coping strategies categorization have been evolutionary, there are three main phases or periods: in the first stage the studies have a strong base on ego and psychoanalysis [15] [16].

In the second stage the coping is regarded as a dynamic process where situational factors and cognitive factors participate in how a personality is molded [17] [18].

The third period bring a renewed perspective of the personality influence, at the same time a strong interaction with coping, an assessment and results from adaptations between elements was regarded [19].

There are just only 2 coping categories even with a long history of research on coping, recently some authors point out a third category, the nature of this recent category seems like a sub-division of no adaptive coping strategy [20] [21] [22], that's because this work tries to extend the spectrum of coping strategies from the perspective of profiles, in order to give more options for students and consequently obtain better results in academic goals.

Even there are a lack of an approach or study that evidence that a coping strategy are better than others in all contexts, there are criteria for a single perspective like time, commonly the best strategy for long term is the approach coping strategy, and in the short term the best strategy is the avoid coping strategy [23].

Another study indicate that adaptive strategies are more suitable in controllable situations and coping strategies no-adaptive are more useful in no controllable situations [24], there is not as clear superiority between strategies, always depend on a specific situation [25].

The adaptive strategies effectivity relies in more factors than the mentioned, like: strong belief that life is significant and worth living [26], the perception of greater control over sources of stress.

Main works about coping strategies categories research are: [17] [27] [28] [29] [30] [31].

Many associations between no adaptive coping strategies and language disorder include dyslexia [26] [32] [33], and perfectionism with emotion [34] [35] [36] [37].

Researchers on coping responses inventory [38] [39], indicates that is more likely that students with language disorder make an intensive use of no adaptive coping strategies [32] [33] [40].

Those persons who has social support has a better self-stem [41], and commonly those persons who has not had social support have negative results in life like school drop, delinquency, unemployment, loneliness, problems in general, a deteriorate mental health is associated with no adaptive strategies [42] [43] [44], adolescent and no adaptive strategies [45] [46] [47].

Most of patients with psychopathological symptoms at mental health institutions use no adaptive coping strategies in a ratio of 2 to 1 [48] [49] [50].

Women tends to use more the no adaptive coping strategies [51], as time passes using this kind of strategy seems that obtain a higher control in their coping process.

2 Methodology

The study was conducted with students from the Universidad Autónoma de Aguascalientes, the methodology to collect data consist of results of a set of activities that may cause a certain level of stress.

The participants did activities like exams and solving problems or complex readings depending on their ages and schooling, followed by interviews and questionnaire where the answers (the questions are listed below) become transformed to profiles using cluster analysis techniques.

Essentially this study is a hierarchical cluster analysis to differentiate groups or clusters.

The sample was 20 people (7 dyslexic people and 13 regular people) all participated by invitation, with many age groups between 12 and 21 years old, the members have been participating in similar activities of previous studies, the participants were studying major in Artificial Intelligence and software engineering.

The training period was very short because of their experience in this kind of studies, the activities consist in reading practices and no-words recognition.

After the activities the participants were told that does not approve the tasks and have to wait if they will do the activities again, in this waiting phase an interview was applied with questions about their decision process in this specific situation.

The interview procedure was based in a series of concrete questions based on the theoretical framework of cognitive-affective processes to help the people to explain their motivations and behavior from Elly Singer [52].

The set of questions were modified in order to get more appropriation to the context of college level.

What do you do in this demanding situation in coping strategy terms ?

1. What do you expect from the used strategy ?
2. Why is important to you to obtain this goals ?

3. What is your feeling in this process ?
4. What do you think make you feel this way ?
5. Did you express your feelings ?
6. Do you feel a certain level of control over the demanding situation ?
7. Did you talk somebody about this process ?

In order to reduce dichotomized answers in the interview we invite reflection rather than short answers, and ask through many perspectives and depth levels.

Interviewer fill the questionnaire with participant answers and evaluate the kind of coping strategy and the kind of stress source.

The building of profile was firstly by clustering and re-clustering of answers, the clustering method was the mountain clustering method because it is relatively simple and effective approach to approximate estimation of cluster centers on the basis of a density measure.

Basically this method was used to obtain initial cluster centers, it is considered as a quick stand-alone method for approximate clustering, is very similar to what a human does visually forming clusters of a dataset.

The process involved iterations of observing every point of overlapping areas or underlying patterns until obtain some level of internal homogeneity in clusters.

Commonly, mountain method is used with more sophisticated cluster algorithms, for this study we used mountain method only because of the small sample.

3 Results

Findings are showed in 4 histograms graphics; first 2 graphics show findings grouped by three main source of stress (family, school, schoolmates), first graphic show results from dyslexic people, second graphic show results of regular persons.

Next 2 graphics show which kind of coping strategy was selected, third graphic show results of regular persons and the fourth and last graphic show the dyslexic people results.

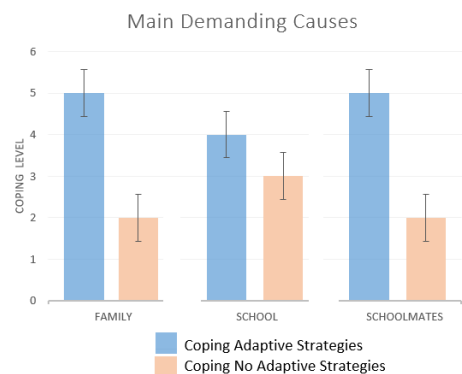


Figure 1. Dyslexic students coping strategies selection results.

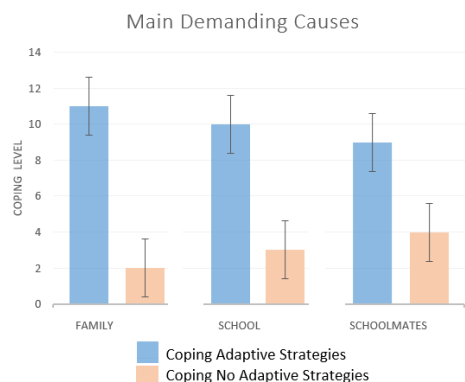


Figure 2. Dyslexic students coping strategies selection results.

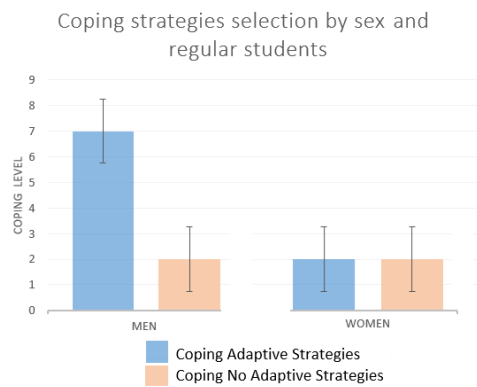


Figure 3. Regular students by sex coping strategies selection results.

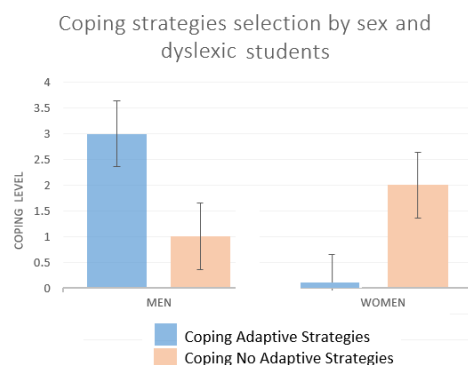


Figure 4. Regular students by sex coping strategies selection results.

Figure 1 show that dyslexic people are in doubt about choose adaptive or no adaptive coping strategies, as if they were in selection process still.

Figure 2 show that regular people insist in choosing adaptive strategies that means they keep trying, that is, show that they are more active or “all hands on deck” approach.

Figure 3 show coping strategy selection separated by sex from dyslexic people, dyslexic men and regular men results are very similar.

Figure 4 show coping strategy selection separated by sex from regular people, is notable that dyslexic women and regular women selections tends more to no adaptive coping strategies, more than men in the same category, this tendency is more in dyslexic women than in regular women.

Most of the findings of this study are consistent with the results of other studies, like other studies the size of sample is small and as consequence is hard to generalize the findings.

Profiles results

The building of profiles was through analysis of cluster and re-clustering of overlapping groups until obtain differentiated groups that become in profiles.

Profile 1: this group were very oriented to coping adaptive strategies, only 7% has doubt about adaptive or no-adaptive strategy, but these persons even that does not express their concerns or problems are in active expectation to solve their task or problems, are self-motivated, most of the people belongs to regular person group.

Profile 2 this group has a lot of doubts not just to choose a strategy from the same kind of strategies but to choose between strategy categories, these persons doubt about do nothing or stay on “active expectation” to solve their situation, from here can be derived at least 3 sub-profiles and all depend of family, school and schoolmates support, most of these profiles are dyslexic.

Profile 3 like profile 2 has a lot of doubts not just to choose a strategy from the same kind of strategies but to choose between strategy categories, this group does not do “active expectation”, they can use resources from family, school or schoolmates although they are not explicitly waiting it, this profile has high variability depending of the quality of the resources of family, school or schoolmates that is why is plausible to derive at least 3 sub profiles.

4 Conclusions and future work

As first contribution we emphasize the double role of main source of stress (family, school, schoolmates) first role is as source of stress, second role as a support network always depending of the quality of the support, from this double role we suggested 3 profiles and 6 sub-profiles, the methodology was a modified instance from Singer [52] methodology.

We suggest that the complexity of coping strategies very much depend of double role of some of its components, the variety in the time of using these strategies as well.

In this kind of studies maybe the most challenging obstacle is achieving a greater size of sample, most of the studies in this area work with small samples.

As future work we will focus on a deep analysis of nature and different kinds of social support than family, school and schoolmates can give and how it can influence the coping strategies selection.

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Jigsaw Colaborativo con Realidad Aumentada para Geografía de Primaria: Propuesta de Prototipo con los 5 Municipios de Baja California Sur

Collaborative Jigsaw with Augmented Reality for Elementary School Geography: Prototype Proposal with the 5 Municipalities of Baja California Sur

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Resumen. En la educación primaria, la enseñanza de la geografía presenta un reto: combinar la comprensión de espacios y territorios con dinámicas activas de trabajo en equipo. El método Jigsaw, reconocido por fomentar la responsabilidad individual y la colaboración, suele hacer uso de materiales impresos y requiere múltiples dispositivos o espacios. Para abordar estas limitaciones, el presente trabajo propone un prototipo de aplicación web que digitaliza la técnica Jigsaw mediante Realidad Aumentada (RA) y códigos QR, aplicado al estudio de los cinco municipios de Baja California Sur: Mulegé, Loreto, Comondú, La Paz y Los Cabos. En la fase experto, cada estudiante asume el rol de experto en un municipio, escaneando el marcador QR asignado para interactuar con un modelo 3D y escuchar un audio con información complementaria. La actividad continúa con una fase mosaico, en la cual los estudiantes reúnen los códigos QR, cuya combinación despliega un modelo 3D que representa el territorio completo y se finaliza con la resolución de un breve cuestionario que refuerza la integración del conocimiento. Este documento detalla el prototipo funcional, incluyendo su arquitectura técnica, el flujo de interacción y presenta los resultados de una evaluación heurística de usabilidad en entornos de RA; dichos hallazgos validan la viabilidad técnica y ofrecen pautas para su adopción pedagógica.

Palabras Clave: Jigsaw, realidad aumentada, geografía, primaria, prototipo, Baja California Sur, QR.

Summary. In primary education, teaching geography presents a challenge: combining the understanding of spaces and territories with active teamwork. The Jigsaw method, known for fostering individual responsibility and collaboration, typically uses printed materials and requires multiple devices or spaces. To address these limitations, this paper proposes a web application prototype that digitizes the Jigsaw technique using Augmented Reality (AR) and QR codes, applied to the study of the five municipalities of Baja California Sur: Mulegé, Loreto, Comondú, La Paz, and Los Cabos. In the expert phase, each student assumes the role of an expert for one municipality, scanning their assigned QR code marker to interact with a 3D model and listen to an audio recording with supplementary information. The activity continues with a mosaic phase, in which students collect the QR codes. Combining these codes displays a 3D model representing the entire territory, and the activity concludes with a short quiz that reinforces the integration of knowledge. This document details the functional prototype, including its technical architecture, interaction flow, and presents the results of a heuristic usability evaluation in AR environments; these findings validate the technical feasibility and offer guidelines for its pedagogical adoption.

Keywords: Jigsaw, augmented reality, geography, primary, prototype, Baja California Sur, QR.

1 Introducción

La enseñanza de la geografía en educación primaria, dentro del marco de la Nueva Escuela Mexicana, se integra en el campo formativo Ética, Naturaleza y Sociedades. A partir de cuarto grado, se introduce la noción de espacio geográfico y cartografía, mientras que en quinto grado se refuerza el estudio de la división política (mapas estatales, municipios y sus cabeceras) como parte de sus planes y programas de estudio[1]. Tradicionalmente, se utilizan recursos como mapas impresos, fotografías y lecturas, los cuales pueden presentar limitaciones como: baja interactividad, escasa colaboración simultánea y la falta de retroalimentación inmediata. Como resultado, se vuelve más complejo formar un aprendizaje colaborativo y dinámico.

Para fomentar experiencias más activas y colaborativas, el método Jigsaw divide los contenidos en segmentos, asignando a cada alumno el rol de “experto” en un subtema, y posteriormente reunir al grupo para que cada uno comparta sus hallazgos y se construya el conocimiento de forma colectiva. Sin embargo, aplicar esta técnica en la enseñanza de la geografía requiere el uso de múltiples copias de mapas y espacios tanto para la fase experto como para la fase mosaico, lo que dificulta su implementación en aulas con recursos o espacios limitados.

Este artículo presenta el diseño de un prototipo de aplicación web que implemente el método Jigsaw con Realidad Aumentada (RA) y códigos QR, centrado en el estado de Baja California Sur y sus municipios (Mulegé, Loreto, Comondú, La Paz y Los Cabos). Tras la descripción de la secuencia de aprendizaje (fase experto y mosaico) y de su arquitectura técnica, el prototipo es objeto de una evaluación de usabilidad mediante una revisión heurística adaptada a entornos de RA. Esto con el fin de validar su viabilidad técnica y adopción pedagógica.

2 Estado del Arte

2.1 El método Jigsaw en el aula

Desde su creación, el método Jigsaw, también conocido como método del rompecabezas, ha sido implementado como estrategia de aprendizaje cooperativo en primaria y secundaria. Aronson et al. [2] proponen este método como una respuesta a la necesidad de mejorar tanto el rendimiento académico como las relaciones interpersonales en entornos escolares diversos (étnicos, académicos, socioeconómicos y lingüísticos). Jigsaw asigna un tema general a un grupo con cuatro o más integrantes, denominado grupo base. Este tema se divide en subtemas, los cuales se asignan individualmente a cada miembro del grupo. Quienes comparten el mismo subtema se reúnen temporalmente en un grupo de expertos para un análisis de manera colaborativa. Una vez estudiado el contenido, los estudiantes regresan a su grupo base y comparten lo aprendido con el resto de los integrantes (Figura 1). Este enfoque fomenta la responsabilidad individual, la interdependencia positiva y desarrollo de habilidades sociales. La implementación descrita por Aronson demostró no sólo beneficios académicos, sino también una disminución significativa en actitudes negativas y prejuiciosas entre los estudiantes [2]. Más recientemente, Mohebbi et al. [3] implementaron con éxito el método Jigsaw en un entorno digital, combinándolo con el modelo de aula invertida. A través del trabajo en grupos, el estudio evidenció mejoras en habilidades de comunicación y pensamiento crítico en los estudiantes.

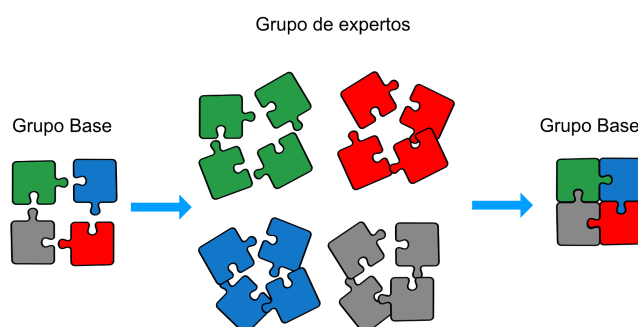


Figura 1. Etapas del método Jigsaw: grupo base, grupos de expertos y grupos base con conocimiento integrado.

2.2 La Realidad Aumentada en la enseñanza de la geografía

La realidad aumentada (RA) es una tecnología que ha ganado cada vez más auge. Azuma [4] define la RA como la capacidad de ver el entorno real con objetos virtuales superpuestos (Figura 2). En el ámbito educativo, la RA resulta especialmente útil para la enseñanza de la geografía, facilitando la interacción con modelos tridimensionales y objetos espaciales, lo que favorece a mejorar la percepción espacial y la comprensión de conceptos cartográficos [5].

Además de estos beneficios visuales y espaciales, algunos estudios han documentado cómo la RA aumenta la motivación, el compromiso y facilita la retención de información al ofrecer experiencias multisensoriales con la combinación de lo visual, auditivo y kinestésico [6]. Trabajos recientes han reportado una posible reducción en la carga cognitiva en los estudiantes al utilizar entornos de AR, aunque los resultados no fueron estadísticamente satisfactorios en todos los escenarios [7].

Un ejemplo destacado de proyectos de RA es el AR Sandbox, desarrollado por la Universidad de California en Davis. Este sistema permite a los estudiantes modelar con las manos un terreno en una caja con arena real, mientras que un proyector superpone un modelo sobre el relieve creado con la arena, además de simulaciones de flujo de agua en tiempo real. La combinación de interacciones físicas y representaciones virtuales facilita la

comprensión de conceptos como la elevación, escurrimiento y topografía, convirtiéndolo en una herramienta efectiva para la enseñanza de la geografía [8].

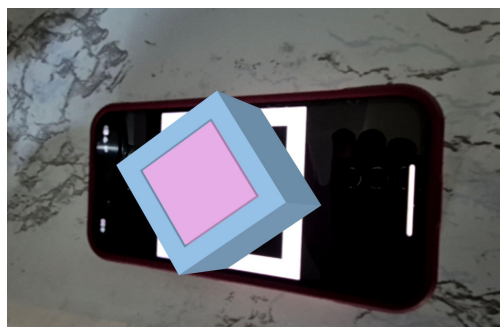


Figura 2. Ejemplo de realidad aumentada superponiendo un modelo 3D sobre un código QR.

3 Resultados

Para el desarrollo del prototipo se definió una metodología en tres etapas. En la primera etapa se define la secuencia de aprendizaje, diseñada para alumnos de cuarto grado de primaria (9-10 años), en la que se establecen dinámicas cooperativas, orientadas al método Jigsaw. La segunda etapa consistió en el diseño de la aplicación utilizando tecnologías web y estándares abiertos, con el objetivo de garantizar la compatibilidad multiplataforma. Finalmente, se realizó una evaluación heurística de usabilidad adaptada a entornos de realidad aumentada, con el fin de identificar mejoras antes de su aplicación en entornos educativos reales.

3.1 Secuencia de aprendizaje

La secuencia de aprendizaje adaptada a la metodología Jigsaw centrada en un entorno AR se compone:

Objetivo del aprendizaje. Con esta actividad se pretende que los estudiantes no solo adquieran conocimientos cartográficos y la capacidad de reconocer la forma y límite de los municipios, sino que desarrollen habilidades de explicación y comunicación, así como la cooperación y responsabilidad individual.

Grupo base. Equipo de cinco alumnos, cada uno asignado a un municipio del estado de Baja California Sur (Mulegé, Loreto, Comondú, La Paz, Los Cabos).

Grupo experto. Cada alumno asignado a un municipio se reúne con quienes comparten el mismo subtema. Utilizando un dispositivo con cámara y acceso a internet, escanea el código QR para desplegar en realidad aumentada la silueta del municipio (Figura 3). Simultáneamente, se reproduce una narrativa que describe las principales características geográficas y territoriales. El grupo experto discute y profundiza esta información. Tiempo estimado 10-15 minutos.



Figura 3. Visualización del municipio de La Paz durante la fase experto.

Fase mosaico. En esta fase, los estudiantes se reincorporan a su grupo original. Se concentran los 5 códigos QR para formar un mosaico, el cual al ser escaneado, muestra un modelo 3D interactivo del estado de Baja California Sur (Figura 4). De manera colaborativa, cada miembro expone la información de su municipio mientras

exploran el modelo. La actividad concluye con un cuestionario guiado por el docente. Tiempo estimado 15-20 minutos.

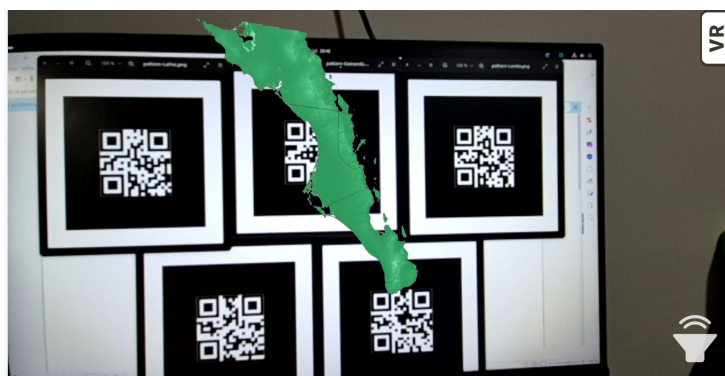


Figura 4. Visualización en RA del modelo 3D de Baja California Sur durante la fase mosaico del método Jigsaw.

3.2 Desarrollo del prototipo

El prototipo se desarrolló sobre una base de tecnologías web estándar para garantizar compatibilidad en navegadores de escritorio, móviles y tabletas. La estructura se definió con HTML5, mientras que utilizó CSS3 para la presentación visual y JavaScript en su especificación ECMA-262 para el manejo de eventos, manipulación del DOM. Además, se integró la API Web Speech [9] para la síntesis de audio, de modo que cada modelo en la fase experto puede ir acompañado con una narración, ofreciendo información hablada sin la necesidad de depender de plugins externos.

Para la experiencia de realidad aumentada en el navegador, se emplea una arquitectura que combina AR.js y A-frame. AR.js [10] aporta un motor ligero especializado en el reconocimiento de códigos QR, seguimiento de imágenes y geolocalización. Por su parte, A-frame [11] es un framework para la construcción de experiencias con realidad virtual (RV). Al estar basado en HTML, garantiza una amplia compatibilidad con múltiples dispositivos y plataformas.

Los modelos 3D de las siluetas se generaron a partir de Modelos Digitales de Elevación (DEM) a 30m de resolución (USGS/NASA) procesados en QGIS.

Los códigos QR se generan con patrones de alta redundancia y contraste para asegurar la robustez de detección en ángulos de hasta 60° y distancias de 20-25 cm.

3.3 Evaluación heurística de usabilidad

Para asegurar que el prototipo ofrezca una versión estable, accesible y alineada con las necesidades del aula, se aplicó una evaluación heurística basada en los principios de Nielsen [12] más dos criterios específicos de RA (robustez de detección y estabilidad visual). La revisión fue realizada por 3 evaluadores internos, utilizando como instrumento un checklist de 15 ítems que cubren aspectos claves de usabilidad, accesibilidad o rendimiento durante las fases experto y mosaico. Cada hallazgo identificado fue calificado con una escala de severidad de 0 (sin problema) a 4 (crítico).

4 Resultados

La inspección heurística de los 15 ítems del checklist proporcionó datos sobre la experiencia de usuario del prototipo. Cada puntuación obtenida se promedió entre los tres evaluadores. En términos generales, el prototipo muestra una base sólida en la consistencia de gestos y navegación, mientras que reveló carencias en la retroalimentación al usuario y la prevención y recuperación de errores. A continuación se presentan en la Tabla 2 los promedios de severidad obtenidos.

Tabla 2. Resultados de la evaluación heurística (promedio de severidad).

No	Ítem de verificación	Promedio de severidad
1	Feedback inmediato al escanear un código QR.	3.0
2	Indicador de progreso claro mientras se carga el modelo 3D.	4.0
3	Texto flotante no interfiere con la manipulación del modelo 3D.	0.7
4	Botón “salir” accesible en todo momento para cerrar la escena AR.	3.7
5	Gestos táctiles (rotar, zoom) funcionan de manera uniforme en todas las fases	0.3
6	Mensajes preventivos que orientan al alumno antes de intentar el escaneo.	2.7
7	Iconos y leyendas de las acciones disponibles siempre visibles.	3.0
8	Accesos rápidos (botones o gestos) para avanzar o retroceder sin perder contexto.	2.4
9	Posibilidad de pausar o reanudar la narración de audio en cualquier momento.	3.7
10	Interfaz limpia, sin elementos superfluos que distraigan del contenido esencial.	0.7
11	Contraste visual apropiado entre elementos interactivos y el fondo real.	1.0
12	Proporcionar mensajes que no solo informen del fallo sino que expliquen la causa y cómo corregirla.	2.3
13	Botón de ayuda siempre visible que despliegue una guía interactiva con descripciones de fases, controles y gestos.	3.0
14	Reconocimiento fiable de los QR en ángulos de hasta 60° y diversas condiciones de iluminación.	1.0
15	Modelos 3D permanecen estables, sin saltos ni parpadeos, al mover el dispositivo o cambiar de fase	1.0

4.1 Análisis de hallazgos

Los hallazgos más críticos de la evaluación presentaron una severidad ≥ 3.0 . La retroalimentación de escaneo (ítem 1) resulta insuficiente, no confirma con claridad cuando el QR ha sido reconocido correctamente. Asimismo, el indicador de carga del modelo (ítem 2) no se encuentra presente, en cuanto al botón salir (ítem 4) no comunica bien su función, mientras que los íconos y leyendas sobre las acciones y el botón de ayuda (ítems 7 y 13) no están presentes en algunos escenarios. Por último el control de audio (ítem 9) carece de un mecanismo intuitivo.

En el rango moderado ($1 < \text{severidad} < 3$), destacan los mensajes preventivos (ítem 6), los accesos rápidos de navegación (ítem 8) y recuperación tras errores (ítem 12). Estos elementos cumplen con su función, pero requieren ajustes de contexto y claridad para optimizar la usabilidad.

Finalmente, los componentes de bajo impacto (ítems 3, 5, 10, 11 y 15) con una severidad ≤ 1 , destacan por su implementación sólida que garantiza una experiencia estable en condiciones normales en el aula.

Aunque el enfoque actual se centró en la viabilidad técnica, se identificó la necesidad de integrar funcionalidades de accesibilidad. La implementación de la API de Web Speech, abre la posibilidad de incluir dentro del prototipo comandos de voz y la generación dinámica de subtítulos, alineándose con los ejes de inclusión de la Nueva Escuela Mexicana.

5 Conclusiones

La integración de metodologías de aprendizaje activo, como el método Jigsaw, con tecnologías inmersivas como la RA, representa una oportunidad significativa como apoyo a la enseñanza de asignaturas como la geografía. Estas herramientas no solo aumentan la motivación del estudiante, sino que también facilitan la comprensión de conceptos abstractos al permitir una interacción directa y colaborativa con el material de estudio.

El prototipo presentado en este trabajo demuestra que, al adaptar el método Jigsaw a un entorno de RA desde el navegador web, es factible diseñar experiencias de aprendizaje colaborativo que no dependan de equipos costosos ni de instalaciones complejas.

La evaluación heurística inicial ha sido fundamental para validar la viabilidad del prototipo. Los resultados indican que la base tecnológica es robusta, con una detección de códigos QR y una estabilidad visual valoradas positivamente. Sin embargo, también se revelaron problemas de usabilidad, principalmente en áreas de control del usuario, retroalimentación del sistema y accesibilidad cuya corrección contribuirá a una experiencia de aprendizaje fluida.

Como trabajos futuros, se propone realizar pruebas con usuarios finales (estudiantes y docentes) en un entorno de aula real para validar la efectividad pedagógica. Además se contempla la expansión de los módulos de contenido para abarcar otras regiones, así como la integración de diferentes capas de información. Finalmente, se explorará la adaptación y validación del prototipo en otras asignaturas y niveles educativos, tanto para educación primaria como secundaria.

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The Metaverse and Digital Art for Artistic Inclusion Through NFTs

El metaverso y el arte digital para la inclusión artística a través de NFT

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Summary. This work explores the metaverse, digital artwork, and Non-Fungible Tokens (NFTs) potential to promote art inclusion and digital gap reduction. An innovative lead is being analyzed: a workshop designed to train emerging artists who create and may commercialize digital artwork through NFTs. The participants were instructed to offer and sell their work in decentralized platforms like OpenSea and manage digital wallets like MetaMask. This workshop ended with an expo in a virtual gallery created on Spatial.io. The insights showed that, although emerging technologies offer unprecedented ways to artistic monetization and expression, the adoption of these technologies requires an approach not only to access the tools but to develop skills, community support, and overcome systematic barriers. This project stands out as practicing digital literacy for the artists to get economic autonomy and to change global views on creativity.

Keywords: Metaverse, NFT, blockchain, inclusion, technologies in education.

Resumen. Este trabajo explora el potencial del metaverso, las obras de arte digitales y los tokens no fungibles (NFT) para promover la inclusión artística y la reducción de la brecha digital. Se analiza una iniciativa innovadora: un taller diseñado para capacitar a artistas emergentes que crean y comercializan obras de arte digitales mediante NFT. Se instruyó a los participantes para que ofrecieran y vendieran su trabajo en plataformas descentralizadas como OpenSea y gestionaran billeteras digitales como MetaMask. Este taller finalizó con una exposición en una galería virtual creada en Spatial.io. Los hallazgos mostraron que, si bien las tecnologías emergentes ofrecen formas sin precedentes de monetización y expresión artística, su adopción requiere un enfoque no solo para acceder a las herramientas, sino también para desarrollar habilidades, el apoyo de la comunidad y superar las barreras sistémicas. Este proyecto destaca por su práctica de la alfabetización digital para que los artistas obtengan autonomía económica y transformen la perspectiva global sobre la creatividad.

Palabras Clave: Metaverso, NFT, blockchain, inclusión, tecnologías en educación.

1 Introduction

The intersection of technology and art expression have been a constant among history, generating new ways to create and divulge. Before photography until the actual digital era, technological tools have continuously redefined art limits, ending in the emerging of digital art as a dynamic media constantly evolving. However, this technological evolution has also shown a significant disparity between access and training, known as digital gap ("Digital art | EBSCO Research Starters," n.d.).

Digital gap makes reference to an access inequality to technological resources and skills, frequently influenced by socioeconomic status, geographic location, and some other factors (Salinas and Dávalos, 2024). On the other hand, digital inclusion means "the activities necessary to ensure that all individuals and communities, including the most disadvantaged, have access to and use of Information and Communication Technologies" (Reisdorf and Rhinesmith, 2020). It's important to acknowledge that digital inclusion must consider several barriers that individuals have to face while interacting with digital technologies.

In this context, the idea of a workshop for training artists so they can offer and sell their artwork emerges as an innovative effort to bridge this gap. The objective of this project is to empower potential artists by providing

practical experience with metaverse, NFTs and blockchain technologies. The workshop not only seeks to introduce new creative tools to artists, but to endow them with knowledge required to navigate and prosper in the emergent digital economy.

Also, we need to understand that technology, by itself, can't guarantee inclusion. Although it offers a huge potential to expand access and opportunities, its existence doesn't ensure equal adoption. As Reisdorf and Rhinesmith (2020) highlight, digital inclusion must be considered a core component of social inclusion, which requires going beyond mere access to technology. Initiatives, like this one, to be really effective in bridging a digital gap, must go further than just a device or platform provision (Digital Inclusion in Education, n.d.). The focus of the workshop, by including detailed training about the use of OpenSea and Metamask, aligns directly with this need, recognizing that the ability of using tools in a significant way is as important as access to those (Carvalho et al., 2023).

1.1 Immersive Spaces

To fully understand the objective of this project, we need to create a solid base by clearly defining what metaverse and digital art are, and so their bond.

So, metaverse or immersive space is a digital 3D space mixed with the real and virtual world, it's a virtual universe created beyond the real world. This term was first coined in a science fiction novel called cyberpunk. The fundamental characteristics of the metaverse include (Zhang et al., 2022):

- A compound of technologies: it is a multiple emergent technology convergence such as Extended Reality (XR), Artificial Intelligence (AI), and blockchain.
- Real and virtual world concurrency: Gathers virtually improved reality with persistent virtual space, almost deleting the gap between both worlds to get a more immersive and multisensorial experience.
- Immersive experience: Takes advantage of virtual reality (VR) and augmented reality (AR) to offer highly realistic and involving experiences.
- Decentralization: It's built over blockchain technology, emphasizing user property over data and digital assets, reducing centralized platform dependence.
- Virtual economic system: Holds a full economy where users can commercialize with digital coins (cryptocurrency), buy virtual goods and invest in digital assets.
- Real time persistence and connectivity: Operates like a virtual world in continuous evolution that doesn't stop when users close their session, allowing events and activities to persist.

There are many applications for metaverse, going from virtual social interaction, digital asset commerce (Andrés, 2023) to immersive education and virtual offices (Zhang et al., 2022).

1.2 Digital art

Referring to digital artwork, it is a kind of visual artwork created or presented using information technology. This genre involves a wide range of media, including digital sculpting, digital cinema, digital beauty arts, digital illustration and digital architecture ("Digital art | EBSCO Research Starters," n.d.). It has transformed the way art is created and it's being experienced, allowing sound, light and video integration within facilities that can be shared and divulged through digital platforms (Damodaran, 2024).

This way, metaverse enables a natural and immersive environment to exhibit and to appreciate digital artwork, granting new ways of interaction going beyond traditional physical galleries (Colella, 2022).

1.3 Blockchain and NFT

To better understand digital artwork and its value as an unique asset, it is necessary to explain what blockchain and Non Fungible Token Technologies are. Thus, blockchain is a system based on the codification and encryption of information (Rivero Moreno, 2024) which takes as a distributed and decentralized append-only database. This kind of system replicates the information across several computational devices (nodes), however this information does not belong to a person/computer but to a single entity conformed by all devices where the blocks (fragments of all the information) are held (Carvalho et al., 2023).

Also, Non Fungible Tokens (NFTs) is an emerging technology provided with the advantages and capabilities of blockchain, becoming a revolutionary digital development platform to represent the ownership and authenticity of digital assets such as artwork, collectibles, and intellectual property (Barua et al., 2025). NFTs, besides previous

examples, can be used in several other contexts like: Issuance and management of certificates, protection of rights, badges, and many others (Di Salvo, 2023).

In addition, NFTs address a big challenge about digital artwork: easy replication and lack of shortages on digital matters. By assigning an unique and verifiable identifier to each work of digital art on blockchain, NFTs turn them into unique pieces, which permits artists to keep the ownership and control of their digital creations, defining terms of property, licence and rights of use (Cole, 2024). Property can be verified through blockchain code, the unique TokenID and contract address. Furthermore, metadata includes information about origin, date, time, and devices used, all of them essential to prove ownership of the original work of art. (NFT Copyright, Ownership & Verification - Artist Guide | Adobe, n.d.).

2 Methodology

The methodology consisted of a workshop centred on guiding participants to create digital art specifically designed to turn it into a NFT. This practical approach promoted a deep comprehension about digital authorship, tokenization and property.

Then, to enable artists to commercialize their work, they were taught to use blockchain key tools. One of them was Metamask, which is a crypto wallet software used to interact with Ethereum blockchain. It has many capabilities like managing and storing account information, making transactions, sending and receiving cryptocurrencies and tokens based on Ethereum (Mai, V. P. G., & Nguyễn, H. V. et al., 2023).

Another of these tools is OpenSea, the biggest NFT commerce platform, which can be considered as a decentralized market built over blockchain technology. Some advantages of this platform are a friendly interface to make buying and selling NFTs in different categories (Nadini, M., Alessandretti et. al., 2021). Participants learned all the steps to mint including connection of Metamask cryptowallet to the platform, uploading digital art files, naming and describing NFTs and to pay associated fees known as “gas rates”. They learned, as well, to set sales with fixed prices and programmed auctions.

3 Developing the immersive experience

Once the participants uploaded their digital art on OpenSea, it was time to exhibit all those works in a virtual gallery, so people could admire them and give notice of the effort, creativity and time spent. That being said, the next step consisted of designing and populating the virtual gallery.



Figure 1. Participants on the immersive experience using VR.

This way, the chosen tool for this task was Spatial.io. This platform is recognized for enhancing millions of interactive worlds and creating virtual and augmented reality immersive environments (Spatial Systems, Inc., s.f.). It offers friendly features for developing spaces without effort, also, it can handle 2D, 3D and video files uploads, allowing artists to exhibit a wide variety of art work inside this virtual space (Zhao, 2024).

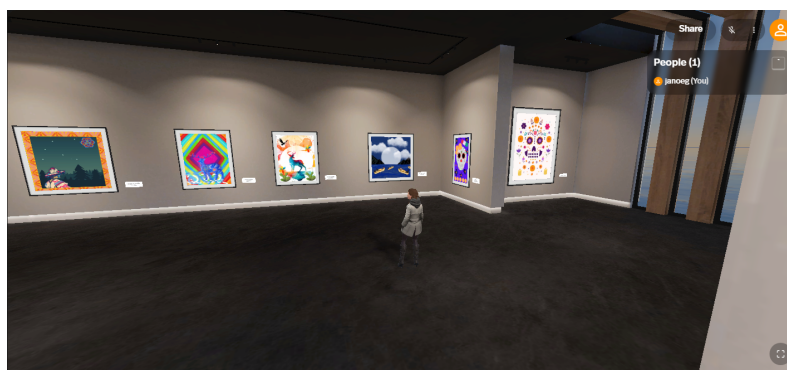


Figure 2. Avatar viewing the VR Gallery view into Spatial.io platform.

Experiences created on Spatial.io can be published directly on the Web, VR/AR and mobile devices, which means users can access Spatial worlds on every device, anywhere, without downloading anything (Hidayati et al., 2024). The 3D environment provided by this platform, surpasses limitations of traditional flat screens and offers new perspectives for presenting art.

4 Experience results

We find that the majority of attendees are from technology degree subjects as shown in workshop engagement data with 74% from technology undergraduate programs. Students enrolled in Informatics programs are most dominant (52 %), after Computer Systems (22 %). That reflects a keener interest in NFTs and blockchain in these sectors. Fifteen percent of the participants were from the field of Economics, 11% from other disciplines. Professor Participation was low (7.6 %), and concentrated mostly around CS and Economics.

Table 1. Participants by academic program.

Academic program	Students	Professors	Total	% of Participation
Economy	12	2	14	15%
Informatics	45	3	48	52%
Computer Systems	18	2	20	22%
Other	10	0	12	11%
Total	85	7	92	100%

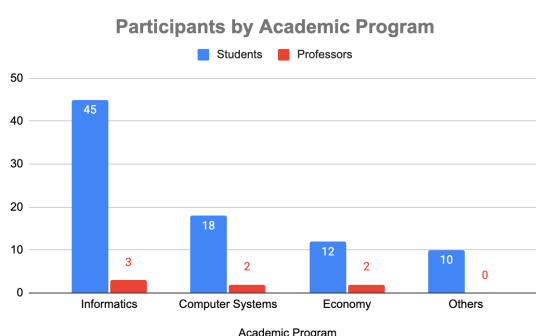
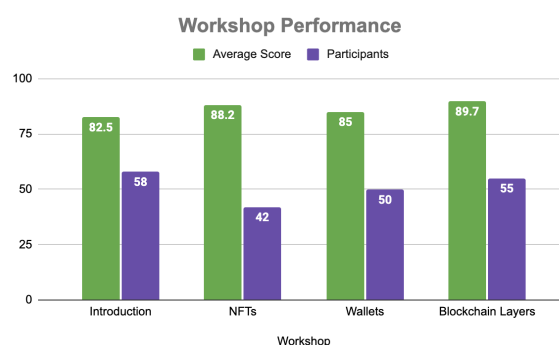


Figure 3. Participant distribution (students and professors) across academic programs.

The average performance scores increased from 82.5% (on the Introduction workshop) to 89.7% (on the Blockchain Layers workshop), evidencing a satisfactory learning curve for technical subjects such as wallets and blockchain layers. On the first day of that workshop, 30% of initial responses listed “centralized system” as one of the defining characteristics of blockchain. However, by the Blockchain Layers workshop, 92% were able to correctly identify these three core layers.

Table 2. Workshop performance.

Workshop	Score	Participants
Introduction	82.5	58
NFTs	88.2	42
Wallets	85	50
Blockchain layers	89.7	55

**Figure 4.** Average participant scores per workshop topic (Introduction, NFTs, Wallets, Blockchain Layers).

5 Conclusions

The hands-on workshop gave artists the tools needed to thrive in the digital art world. We walked them through the entire process - from creating digital artwork to selling it as NFTs on blockchain decentralized platforms. By embracing NFT technology, artists discovered new ways to earn money from their work, reach international audiences, and protect their digital creations through verifiable ownership; all of which can significantly increase an artwork's value.

This workshop served as an inclusive gateway into this emerging field. Encouraging artists to access this experience, narrowing the digital gap by teaching/learning skills like digital art creation using different software, NFT minting, crypto wallet management, and marketplace navigation.

While the digital art revolution brings exciting opportunities, we can't ignore the real challenges it creates when it comes to equal access, things like language differences, spotty internet connections, or simply not having strong enough WiFi (connectivity needs and robust internet access). The Metaverse is particularly tricky this way as a double edge sword; on one hand it can be incredibly inclusive by letting people connect across distances and time zones. But at the same time, it demands better computers and a more reliable internet which ends up excluding others.

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Use and effectiveness of inclusive technologies in decentralized technological institutes in the state of Veracruz, México

Uso y efectividad de tecnologías inclusivas en institutos tecnológicos descentralizados del estado de Veracruz, México

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Summary. The purpose of this article is to analyze the use and effectiveness of inclusive technologies in decentralized technological institutes in the state of Veracruz, Mexico. A quantitative descriptive study was conducted. A survey was administered to the 21 technological institutes to identify the disabilities served, the technological tools available, training on inclusive technology, and perceptions of its effectiveness. The results showed that 95% of the institutes (20/21) serve 117 students with motor disabilities (32%), sensory disabilities (21%), language/communication disabilities (18%), psychosocial disabilities (16%), intellectual disabilities (12%), and multiple disabilities (1%). Only 4 institutes (19%) have inclusive technologies and 3 (14%) use them; there is 1 adapted classroom (5%), 5 have teacher training (24%), and only 1 has protocols (5%), despite the fact that 81% claim to promote inclusion. Those who do use technology rate it as effective (levels 4–5) for performance, retention, and participation. It is concluded that, although Veracruz Technological Institutes have made progress in adopting new technological tools to promote inclusion, it is necessary to optimize their use through greater training, investment, and comprehensive strategies that guarantee their effectiveness and sustainability.

Keywords: inclusive education; technologies; disability; higher education; Veracruz.

Resumen. El propósito de este artículo es analizar el uso y la efectividad de las tecnologías inclusivas en institutos tecnológicos descentralizados del estado de Veracruz, México. Se realizó un estudio descriptivo cuantitativo. Se aplicó una encuesta a los 21 institutos tecnológicos para identificar las discapacidades atendidas, las herramientas tecnológicas disponibles, la capacitación en tecnología inclusiva y las percepciones sobre su efectividad. Los resultados mostraron que el 95% de los institutos (20/21) atiende a 117 estudiantes con discapacidades motoras (32%), discapacidades sensoriales (21%), discapacidades del lenguaje/comunicación (18%), discapacidades psicosociales (16%), discapacidades intelectuales (12%) y discapacidades múltiples (1%). Solo 4 institutos (19%) cuentan con tecnologías inclusivas y 3 (14%) las utilizan; hay 1 aula adaptada (5%), 5 tienen capacitación docente (24%) y solo 1 cuenta con protocolos (5%), a pesar de que el 81% afirma promover la inclusión. Quienes sí utilizan la tecnología la califican como efectiva (niveles 4-5) para el desempeño, la retención y la participación. Se concluye que, si bien los Institutos Tecnológicos de Veracruz han avanzado en la adopción de nuevas herramientas tecnológicas para promover la inclusión, es necesario optimizar su uso mediante mayor capacitación, inversión y estrategias integrales que garanticen su efectividad y sostenibilidad.

Palabras Clave: educación inclusiva; tecnologías; discapacidad; educación superior; Veracruz.

1 Introduction

Inclusive education is a global education policy issue. It can be defined as a positive response to diversity that is identified with the participation, achievements, and removal of barriers for all groups involved, such as students, teachers, families, and communities, becoming a fundamental pillar of international education policies [1]. This approach promotes the full participation of students with disabilities in regular school settings, removing barriers and providing the necessary support for their learning. In Mexico, this commitment is reflected in a robust regulatory framework: the General Law for the Inclusion of Persons with Disabilities [2], the Federal Law to Prevent and Eliminate Discrimination [3], and the General Education Law [4] establish the obligation to ensure equitable access to education for this population. Although inclusive education policy has advanced in formal terms, multiple studies warn that there are still substantial differences between what is established in regulations and the actual practices experienced in higher education institutions [5, 6]. In Mexico, only a small percentage, between 4% and 5%, of people with disabilities manage to access higher education, which shows a significant lag in attention to this sector [6, 7]. In this context, inclusive or assistive technologies are seen as strategic tools for promoting the academic participation of students with disabilities. These tools range from devices such as screen

readers, hearing aids, and adapted keyboards to applications and platforms that facilitate interaction and access to content. According to Puyalto [8], when used appropriately, these technologies can eliminate pedagogical communication barriers, allowing for teaching that is more tailored to the individual needs of students. Similarly, international organizations point out that technology, accompanied by effective pedagogical methodologies, can strengthen inclusive educational processes by offering accessibility and personalization in teaching processes [9]. However, several studies warn that the availability of technology alone does not guarantee inclusion; its effectiveness depends largely on contextual factors, such as teacher training, universal design of educational resources, and institutional support [8, 10].

In Veracruz, decentralized technological institutes (belonging to the National Technological Institute of Mexico but administered at the state level) face the challenge of offering higher technological education to a broad and diverse student body. There are currently 21 such institutes spread across different regions of the state, serving thousands of students in engineering fields. Given the diversity of their student body, it is pertinent to examine the extent to which these centers are equipped and prepared to incorporate technological tools designed for people with disabilities. To date, there has been little specific research on the use of inclusive technologies in these institutions and the perceptions of teachers and administrators in this regard. Analyzing this situation is important for identifying best practices, outstanding needs, and areas of opportunity in the implementation of inclusive education at the higher education level. In this context, the overall objective of this research is to evaluate the use and perceived effectiveness of inclusive technologies in decentralized technological institutes in the state of Veracruz. Specific objectives include: (a) describing the main disabilities of students attending these institutes; (b) identifying whether the institutions have adapted technologies and inclusive software; (c) identify training in the use of inclusive technologies; and (d) analyze how teachers and administrators perceive the contribution of these technologies to improving the learning and integration of students with disabilities. Based on this analysis, the aim is to offer a critical view of the achievements made and the barriers that still exist, in order to propose recommendations that contribute to strengthening inclusive education in the field of technology education. The methodology used is detailed below, the results obtained are presented, and finally, the conclusions and suggestions derived from the study are discussed.

2 Methodology

This study adopts a descriptive quantitative approach, focusing on the application of a survey specifically designed to collect data on the use of inclusive technologies in technological institutes in Veracruz, Mexico. The population covered included the 21 decentralized technological institutes in the state, as they constitute the entire set of state-administered higher education technology centers. The instrument was administered to management personnel and academic coordinators with experience in activities aimed at students with disabilities. Data collection was carried out during June-July 2025 using an electronic form sent by institutional email, thus ensuring broad geographical coverage and ease of participation by the institutions.

The questionnaire consisted of open-ended and closed-ended questions divided into four main sections, in line with the objectives of the research. The first section collected general data on the institution, requesting information on the institution of origin, the respondent's position, the type and number of students with disabilities (motor, sensory, intellectual, psychosocial or mental, language and communication, and multiple), as well as whether the institution has inclusive technologies (such as screen readers, specialized software, and adapted devices). The second section focused on collecting information on the existence or absence of adapted technologies, inclusive software, the use of such technology by teachers, and technologically adapted classrooms for students with disabilities. The third section included questions on teacher training in the use of these technologies, institutional protocols to ensure equitable access to inclusive technologies, and the promotion of a culture of inclusion and respect for diversity. The fourth section of the survey addressed perceptions of effectiveness: using 5-point Likert scales, respondents evaluated how effective they considered the inclusive technologies implemented to improve the academic performance and integration of students with disabilities. Cronbach's alpha was applied to validate the internal consistency of the questionnaire, with an overall value of 0.894.

Once the responses from the schools had been collected (with 100% participation from all 21 schools, equivalent to 100% of the target population), the data was analyzed. For closed-ended multiple-choice questions and Likert scales, descriptive statistics were calculated: absolute frequencies and arithmetic means. Given the relatively small size of the population (21 surveys), the analysis focused on general trends rather than statistically significant inferences. The results are organized below in the order of the specific objectives, complementing the quantitative statistics with qualitative findings to provide a more complete perspective.

It is important to note that ethical considerations were respected throughout the process: participation was voluntary, the confidentiality and anonymity of the institutions and participants was maintained (presenting the data in aggregate form without identifying individual names), and the results focused exclusively on educational improvement. Under this methodological approach, the study aimed to provide an accurate picture of the current situation in Veracruz's technological institutes regarding the use and effectiveness of inclusive technologies for students with disabilities.

3 Results

Desde sus inicios, la acreditación ha aportado enormes beneficios al Sistema Educativo Mexicano; en buena medida, porque siempre ha sido impulsado por personal académico de instituciones preocupadas por la calidad; sin embargo, como todos los procesos, debe ser actualizado de manera regular para seguir gozando de sus beneficios. Algunos de sus aspectos positivos incluyen la mejora de la calidad educativa; su impacto en el posicionamiento y prestigio de los programas educativos e instituciones; también ha generado cambios institucionales en la comunicación, el flujo de información y la integración de los actores académicos [9–11], adicionalmente fomenta la formación continua y mejora en el proceso pedagógico de los profesores; así como una mejor planeación de las tutorías[12]. Otro aspecto muy benéfico de la acreditación en las instituciones de educación superior, ha sido el fortalecimiento de los programas de investigación y su articulación con los posgrados; así como el fomento a la vinculación con los sectores productivo y social [13]. Finalmente, la acreditación también ha sido utilizada como una estrategia de rendición de cuentas [9].

3.1 Profile of students with disabilities served

The data collected reveals that the vast majority of decentralized technological institutes in Veracruz currently serve students with some type of disability. Specifically, 20 of the 21 campuses (95%) reported having at least one student with a disability enrolled in their academic programs. Only one institute reported not having any students with disabilities during the study period. The most common disabilities among the institutions are motor and sensory disabilities (hearing and visual). Motor disabilities (people with reduced mobility or wheelchair users) are present in 16 of 21 technological institutes, or 76%. Sensory disabilities are reported in 11 institutes (52%). On the other hand, 7 out of 21 (33%) report intellectual or developmental disabilities (e.g., Down syndrome, autism, or others that affect cognitive functions). Psychosocial or mental disabilities are present in 8 schools (38%), while language and communication disabilities are identified in 7 (33%). Finally, only one institute (5%) reported having a student with multiple disabilities. These figures reflect that there is significant diversity in special educational needs in the Veracruz technological subsystem, implying varied challenges for institutions in terms of accessibility and adaptations.

Fig. 1 shows the distribution of the 117 students with some type of disability reported by all decentralized technological institutes in the state of Veracruz, Mexico. It can be seen that the largest category corresponds to motor disabilities (37 students; 32%). This is followed by sensory disabilities (visual and hearing impairments) with 25 students (21%); language and communication disabilities with 21 (18%); psychosocial or mental disabilities with 19 (16%); and intellectual or developmental disabilities with 14 (12%). Only one case of multiple disabilities (1%) was reported, i.e., a student with more than one condition.

It should be noted that most decentralized technological institutes in Veracruz report serving at least one student with a disability. On average, each institute serves between five and six students with disabilities, ranging from a single student to a maximum of 23 in one institute. There is a gap in technological coverage, as 20 out of 21 institutes, approximately 95.2%, serve students with disabilities. In addition, 80% of the institutes that have students with disabilities (16 out of 20 institutes) lack inclusive technology. This creates inequality, as the absence of inclusive technologies in most institutes means that students with similar needs receive different support depending on the institution. This result indicates that institutional accessibility policies have not been channeled into infrastructure and technological resources in most schools, and that their adoption does not seem to have been managed or is not part of a budgetary priority in most technological schools. The lack of inclusive technology can create barriers in: access to digital materials, communication, design and implementation of assessments, as well as learning speed, which can negatively impact the performance and retention of students with disabilities.

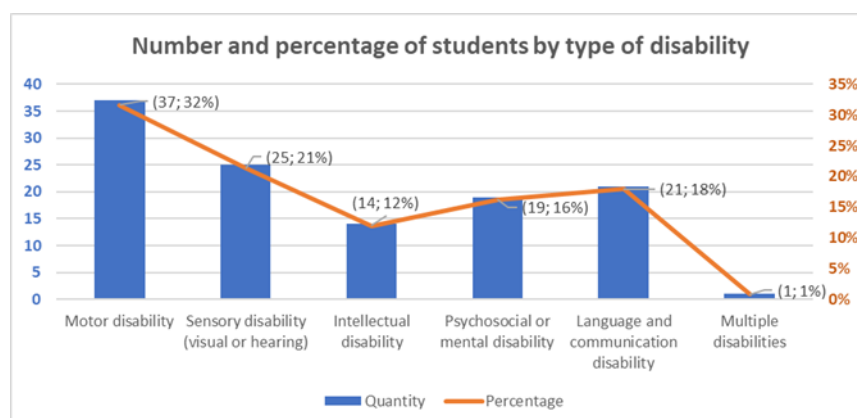


Figure 1. Number and percentage of students by type of disability. Source: Own elaboration

3.2 Infrastructure and technological access

With regard to the technological support tools available in the institutions, the results show a mixed picture. Of the 21 campuses that serve students with disabilities, 4 indicated that they had adapted technologies (screen readers, special keyboards, etc.), equivalent to 19%. The same 4 technological institutes reported having inclusive software (e.g., NVDA, JAWS, accessible Moodle, or other), re-presenting 19%. Of the 21 technological institutes, 4 (19%) reported having inclusive technologies; however, only 3 (14%) use them in their educational activities, which means that 1 technological institute does not use them despite having them. This may be due to problems of insufficient training, lack of curriculum planning, resistance to change, maintenance, or lack of adaptation of materials. Finally, only one institute (5%) reported having technologically adapted classrooms for students with disabilities, which shows a lag in the implementation of technological infrastructure. Fig. 2 presents the data described above.

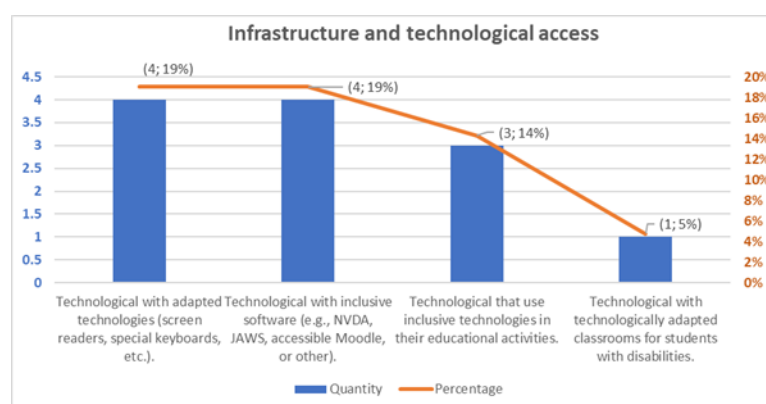


Figure 2. Infrastructure and technological access. Source: Own elaboration

3.3 Teacher training and institutional policies

Another relevant aspect is teacher training and the existence of institutional policies for inclusive technology. Only 24% of the institutes (5/21) stated that their teachers have received specific training in the use of assistive technologies and ICT-supported inclusive education strategies. In most cases, this training has consisted of short workshops or introductory courses organized by the institutions themselves or by organizations such as TecNM. Interestingly, four of the five technical colleges that have received training reported having inclusive technology, but only one of these technical colleges has been trained and does not yet have the technological tools. In terms of institutional policy, only one institute (1/21; 5%), belonging to the four technological institutes that have inclusive technology, reported having institutional protocols in place to ensure equitable access to inclusive technologies. Although 81% of the institutes (17/21) claim to promote a culture of inclusion and respect for diversity, only 19% (4/21) have specific inclusive technologies. This gap of 61 percentage points highlights a discrepancy between institutional discourse and the material resources that enable accessibility, suggesting the

need to transform declarative inclusion into practices supported by infrastructure and technology. Figure 3 presents the resulting data on teacher training and institutional policies.

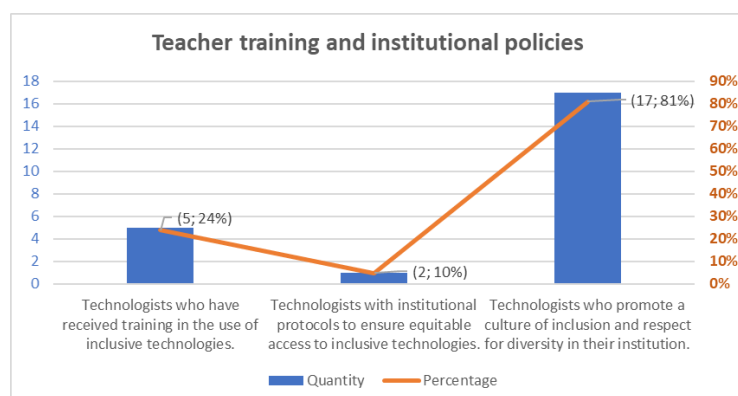


Figure 3. Teacher training and institutional policies. Source: Own elaboration.

3.4 Perception of the effectiveness of inclusive technologies

One of the main focuses of the study was to find out how institutional actors assess the real impact of inclusive technologies on the learning and integration of students with disabilities. In general terms, the perception is favorable, although with some reservations. When evaluating the effectiveness of these tools on a scale of 1 to 5, the four institutes that reported using inclusive technologies selected the highest levels (4 and 5), classifying them as “effective” or “very effective.” These institutes consider that inclusive technologies have been effective in improving the academic performance of students with disabilities, that they have contributed to reducing dropout rates among students with disabilities, inclusive technologies facilitate the social and academic inclusion of students with disabilities within the school, and that significant improvements have been observed in the participation and integration of students with disabilities thanks to the use of inclusive technologies. These participants believe that, thanks to the use of technology, students with disabilities are able to access course content more independently and participate more confidently in academic activities.

4 Discussion

The Veracruz State Expenditure Budget for fiscal year 2025 and its annexes do not include a specific allocation for inclusive technologies for higher education [11]. The document is divided into chapters and administrative units, but “inclusive technologies” or any related term are not found in a specific allocation. If resources are needed for this purpose, they must come from current expenditure or own revenue, which could also cause problems in financial audits. The Ministry of Finance and Planning reiterates that the budget is created under standardized classifications and that there are no specific codes for “assistive technology” in education [12].

The Veracruz Ministry of Education [13] has a Program for Inclusion and Educational Equity (PIEE), but public information does not allocate funds for assistive technology in upper secondary and higher education. Similarly, the National Technological Institute of Mexico reports allocating resources to Decentralized Technological Institutes (ITD), such as the one in Veracruz, in generic budget items, without a specific line item for inclusive technologies. As of September 2025, there is no budget allocation in Veracruz for assistive technologies in higher education. This shows that inclusion is usually financed indirectly, through broader programs (scholarships, academic support, or teacher training) rather than specific budget lines.

Master plans, such as the Veracruz Development Plan [14] and the Veracruz Comprehensive Education Program [15], consider inclusive education a right, in line with the National Development Plan [16] and the United Nations (UN) [17]. However, they are largely declarative in nature, in the sense that they do not establish specific financing mechanisms. Although the SEV reports providing inclusion support to more than 24,000 students, this support is limited to basic education. In higher education, on the other hand, technological investment remains a black box. The National Association of Universities and Institutions of Higher Education (ANUIES) [18, 19] and the Ministry of Public Education (SEP) [20] promote inclusion in higher education and the incorporation of technologies in this context. The University of Veracruz (UV) is a state example of educational accessibility, but

it also lacks transparency in its spending on accessible technology. In general, Veracruz has an inclusive discourse, but no budget.

The results of this research illustrate this disparity: although 95% of ITDs serve students with disabilities, only 19% have adapted technologies, 24% offer teacher training in inclusion, and only 14% use assistive technology in the classroom. This difference between what is said and what is done coincides with previous studies that have already pointed out the gap between regulations and reality in Mexican higher education [5, 6].

Even so, decentralized technologies that have inclusive technologies implemented report positive results: improvement in retention, performance, and participation of students with disabilities, with high ratings on the Likert scale (4-5). This result is consistent with the international literature [8, 21-23], which highlights the potential of digital technologies not only as pedagogical support tools, but also as agents of innovation in teaching, assessment, and collaboration. In this sense, their implementation also responds to international commitments such as the Salamanca Statement [24] and the General Law for the Inclusion of Persons with Disabilities [3].

However, the success of these actions depends on cultural and educational factors. There is still resistance to change, a lack of knowledge about technology, and a lack of specific teacher training. As indicated in [10], professional training in inclusive education is a cornerstone for developing accessible environments. In Veracruz, these restrictions are exacerbated by the unequal distribution of resources among schools, reproducing educational inequalities.

In Mexico, Mexico City has broad social programs (such as best school or transportation scholarships) that, without being called “assistive technology,” have an impact on reducing access barriers. In Jalisco, the State Program for Inclusion and Disability normalizes an inclusive approach (without disaggregation by university), a programmatic advantage compared to Veracruz. At the Latin American level, countries such as Chile have calls for funding for technical aids through [25], Colombia has generated national guidelines for inclusive education with technological components, and in Ecuador, the distribution of ICT has favored student participation [23]. This difference means that Veracruz lags behind other states and countries in the region where technological inclusion has been institutionalized and even explicitly funded.

Evidence also shows the impact of cultural barriers on technology adoption. [26] has warned that inclusion requires not only resources but also a cultural shift that eradicates stigma and promotes reasonable accommodations. These attitudinal barriers, coupled with a lack of institutional awareness and specialized support, have an impact similar to physical barriers [27-29]. In intercultural contexts, linguistic and ethnic barriers still exist that widen inequality. If these aspects are not taken into account, inclusive technology may be underutilized, failing to improve retention and learning.

In this context, the case of Veracruz is justified by three gaps: 1) budgetary, as there are no earmarked funds for the purchase and maintenance of inclusive technologies; 2) programmatic, as strategic plans (PVD, PVEI) do not include financing schemes for higher education; and 3) cultural/educational, due to resistance to change and a lack of teacher training. Comprehensive measures are needed to close these gaps: creating a cross-cutting budget annex for accessibility, a state catalog of consolidated purchases, micro-credential programs in digital accessibility, Regional Accessibility Centers, and a public monitoring system with impact indicators.

In sum, despite Veracruz's recognition of inclusion in its programmatic discourse, it lags behind entities such as Mexico City and Jalisco, and even further behind countries such as Chile and Colombia, which have explicit policies and funding. To advance toward educational equity, it is necessary to align budgets, programs, and institutional culture, ensuring not only the availability of inclusive technologies but also their pedagogical and cultural integration into higher education.

5 Conclusions

In summary, the use and effectiveness of inclusive technologies in Veracruz decentralized technological institutes have made significant but insufficient progress. Although virtually all institutes serve students with disabilities and express a favorable stance toward inclusion, only a minority have assistive technologies and trained personnel to use them. Those campuses that have adequately implemented these tools confirm their beneficial potential, reporting improvements in academic performance and participation among students with special needs. However, most institutions have not yet fully integrated inclusive technology into their educational processes, revealing a gap between inclusive rhetoric and operational reality. Based on the findings, the following practical recommendations are proposed to strengthen technological inclusion in these institutions: ongoing teacher training, investment in accessible resources, institutional policies and protocols, and collaborative networks on inclusive technologies.

In conclusion, Veracruz's decentralized technological institutes have taken initial steps toward technology-supported inclusion, but they still face considerable challenges in consolidating truly inclusive higher education.

Closing the identified gap will require sustained institutional commitment, comprehensive strategic planning, and the allocation of adequate resources. Only through a combination of political will, human capital development, and equitable provision of supportive technology can the promises of inclusive education become tangible realities in Veracruz classrooms and throughout the country. The experience documented in this paper can serve as a reference and starting point for promoting concrete improvements; the path to full inclusion is an evolving process, but the results obtained provide guidance on where to focus efforts and reinforce the conviction that, with the right support, no student should be left behind in their right to a quality education.

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Generative AI Facilitating Image Recognition for the Visually Impaired in Online Learning

IA generativa que facilita el reconocimiento de imágenes para personas con discapacidad visual en el aprendizaje en línea

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Summary. Visually impaired learners often face significant challenges when accessing online educational videos, particularly programming tutorials that rely heavily on visual elements. Traditional teaching resources rarely consider accessible formats, resulting in limited participation of visually impaired students in STEM learning. This study proposes an Artificial Intelligence (AI)-powered system called Image Narrator, which incorporates a Chrome extension, YouTube plugin, and accessible website to support visually impaired learners in understanding video-based instructional content. By leveraging advanced generative AI and computer vision technologies, the system extracts text and visual elements from video frames and converts them into accessible descriptions or screen-reader-friendly formats. A user study involving 24 participants, including visually impaired learners, was conducted at the Canadian National Institute for the Blind (CNIB). Results indicate high satisfaction with the system's image recognition, auto-generated exercises, question-and-answer functions, and overall usability, demonstrating that AI-powered visual narration can effectively reduce learning barriers and enhance independent learning for visually impaired students.

Keywords: Generative AI, Computer vision, Assistive technology, Visually impaired learners, Online learning accessibility.

Resumen. Los estudiantes con discapacidad visual suelen enfrentar desafíos significativos al acceder a videos educativos en línea, en particular a tutoriales de programación que se basan en gran medida en elementos visuales. Los recursos didácticos tradicionales rara vez consideran formatos accesibles, lo que resulta en una participación limitada de los estudiantes con discapacidad visual en el aprendizaje de STEM. Este estudio propone un sistema impulsado por Inteligencia Artificial (IA) llamado Narrador de Imágenes, que incorpora una extensión de Chrome, un complemento de YouTube y un sitio web accesible para ayudar a los estudiantes con discapacidad visual a comprender el contenido instructivo basado en video. Mediante el uso de tecnologías avanzadas de IA generativa y visión artificial, el sistema extrae texto y elementos visuales de fotogramas de video y los convierte en descripciones accesibles o formatos compatibles con lectores de pantalla. Se realizó un estudio de usuarios con 24 participantes, incluidos estudiantes con discapacidad visual, en el Instituto Nacional Canadiense para Ciegos (CNIB). Los resultados indican una alta satisfacción con el reconocimiento de imágenes, los ejercicios autogenerados, las funciones de preguntas y respuestas y la usabilidad general del sistema, lo que demuestra que la narración visual impulsada por IA puede reducir eficazmente las barreras de aprendizaje y mejorar el aprendizaje independiente de los estudiantes con discapacidad visual.

Palabras Clave: IA generativa, visión artificial, tecnología de asistencia, estudiantes con discapacidad visual, accesibilidad al aprendizaje en línea.

1 Introduction

Access to online learning materials remains a significant barrier for the visually impaired, despite advancements in artificial intelligence and digital education. Globally, over 250 million individuals are visually impaired, limiting their employment opportunities and hindering their participation in STEM education. Existing STEM curricula rely heavily on visual demonstrations, such as block-based programming and video tutorials, making it difficult for visually impaired learners to engage in mainstream instruction.

Tools such as tactile systems and Microsoft's Code Jumper have attempted to address these challenges; however, most programming education tools still lack complete accessibility support. Studies consistently indicate that visually impaired learners face barriers related to navigation, formatting, and access to digital content, often relying on interpersonal assistance for information acquisition.

Recent advancements in AI—including machine learning, deep learning, and computer vision—enable new possibilities for assistive learning tools. These include image recognition, audio narration, and content interpretation. While companies such as Microsoft, NavCog, and Horus have developed AI-based mobility or object-recognition tools, few focus on improving access to educational resources or decoding instructional videos.

Therefore, there is a critical need for specialized AI tools that support the academic learning needs of visually impaired students.

This study presents *Image Narrator*, an AI-enabled learning support system designed to extract, interpret, and convert visual information from online instructional videos into accessible formats. The system aims to improve the autonomy and learning effectiveness of visually impaired students in online environments.

2 Existing accessibility systems and tools

El aprovechamiento o logro escolar, se refiere al nivel de conocimientos de un alumno comparado con la norma de edad y nivel académico. Normalmente para valorarlo, éste es medido mediante una evaluación; sin embargo; como todos los problemas complejos, se trata de un fenómeno multifactorial; y aunque se manifiesta a lo largo de un periodo específico, a través de una calificación cuantitativa, no es el producto de una única aptitud.

2.1 NVDA (NonVisual Desktop Access)

NVDA is a free, open-source screen reader widely used in both educational and professional settings. It converts on-screen elements into speech or braille and provides robust support for web navigation, document reading, and software operations, offering a cost-effective accessibility solution. [5].

2.2 JAWS (Job Access With Speech)

JAWS is a commercial screen reader that provides comprehensive accessibility for tasks ranging from text reading to programming. Its extensive functionality allows visually impaired users to operate a wide range of software tools effectively. [4].

2.3 ChromeVox

ChromeVox is Google's built-in screen reader for Chrome OS and Chrome browser users. It supports keyboard navigation, speech output, structural navigation, and auditory cues (earcons), enabling blind and low-vision users to browse web content efficiently. [2].

1. Designed for Chrome OS: While it works on all platforms running Chrome, ChromeVox is primarily designed for Chromebooks.
2. Keyboard Commands: ChromeVox provides a set of keyboard shortcuts that allow users to navigate, select, and perform actions.
3. Speech Output: ChromeVox speaks the currently selected or pointed-to content and offers adjustable speech speed and volume.
4. Navigation Support: Users can quickly navigate to different parts of a webpage, such as headings, links, or lists, using specific keyboard commands.
5. Earcons: These are sound effects used to indicate different events or states, such as a new window opening or a page loading.

3 System Architecture and Demonstration

This system architecture, called 'Image Narrator', illustrates the workflow of an AI-powered educational support platform that integrates accessible web content, Chrome extension services, and an AI assistant. The architecture is organized into five conceptual layers: Presentation Layer, Flow Logic, Application Layer, Business Logic, and Data Access Layer, each representing distinct responsibilities in the system pipeline. The primary goal is to support visually impaired users or learners with special needs by recognizing video content, generating questions, and enabling intelligent interaction with AI (see Figure 1).

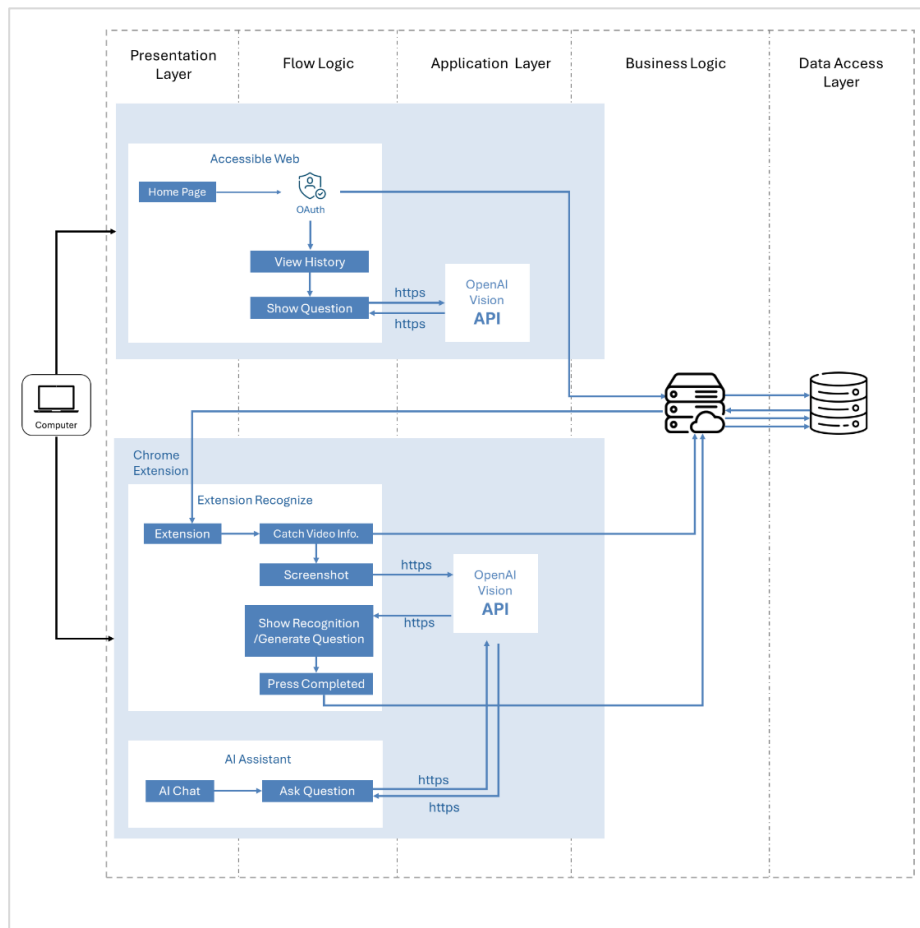


Figure 1. System Architecture of *Image Narrator*.

3.1 Presentation Layer

Includes the accessible web portal, Chrome extension, and AI assistant. Users can authenticate, view learning history, capture screenshots from YouTube videos, and ask questions through the AI assistant.

- **Accessible Web:** Users authenticate via OAuth and can access a personalized homepage where they can:
 - View previously generated questions through the "View History" function.
 - Interact with questions via the "Show Question" interface.
- **Chrome Extension:** A browser-based plugin that captures real-time video content for processing and analysis.
- **AI Assistant:** A chat-based interface allowing users to engage in natural language interactions by posing and receiving questions derived from multimedia content.

3.2 Flow Logic

Controls interactions between users and the system. The extension captures video frames, processes screenshots, sends them to the AI model, and returns recognized text and questions.

- **Accessible Web:** After user authentication, the system fetches stored question data or calls the OpenAI Vision API to interpret visual information.
- **Extension Recognize Module:**
 - Captures video content metadata via "Catch Video Info."
 - Takes screenshots at relevant intervals for analysis.
 - Sends visual content to the AI API for recognition.
 - Returns the generated question or recognized content to the user.

- Enables the user to confirm the process by pressing "Completed."
- **AI Chat:** Allows users to send a question prompt, which is processed via API calls and returns a response accordingly.

3.3 Application Layer

Handles direct communication with the OpenAI Vision API, enabling image recognition, content extraction, and question generation via HTTPS requests.

- HTTPS requests are sent from both the web interface and the Chrome extension to the Vision API.
- The API responds with recognized entities or contextual descriptions that are used to generate educational questions or assistive content automatically.

3.4 Business Logic

Manages application rules, question templates, user history retrieval, and the coordination between API results and interface elements:

- Matching visual content to appropriate question templates.
- Storing and retrieving question-answer pairs based on user history.
- Routing user interactions from various components (web, extension, assistant) to a centralized logic processor.

3.5 Data Access Layer

Stores user data, recognition outputs, question sets, and authentication information in a secure database:

- A database system for storing:
 - User credentials and OAuth tokens.
 - Visual recognition results.
 - Generated questions and user interaction history.
- Secure communication between the logic layer and the database to ensure privacy and integrity.

3.6 System Demonstration

Screenshots from instructional videos are recognized as text and narrated aloud via screen readers (Figure 2). Users can ask questions, receive AI-generated practice exercises, and maintain learning records through the accessible website.

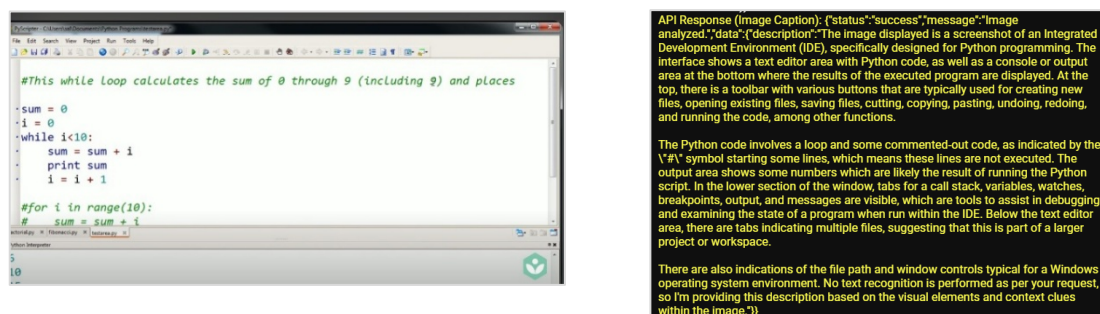


Figure 2. A screenshot of programming learning from an online video.

Users can also ask the AI assistant questions to get answers easily. Image Narrator can also provide several questions for testing based on the screenshot images the user provided before. They can practice the related questions from AI to gain a deeper understanding of the topics (see Figure 3).

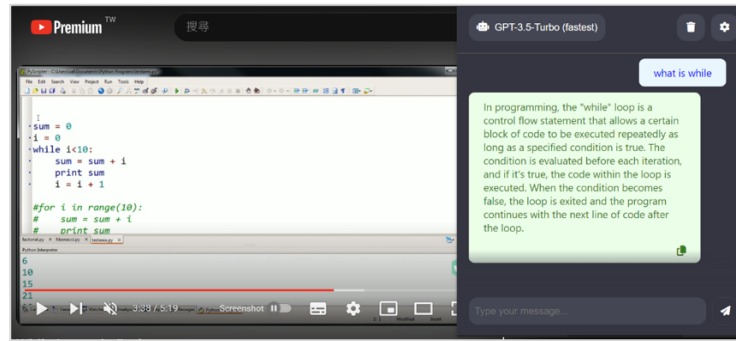


Figure 3. AI questions for practicing on Image Narrator.

This system can also help the user save learning records to help them take online notes on the website. Each screenshot will save its learning content into the database system (see Figure 4).

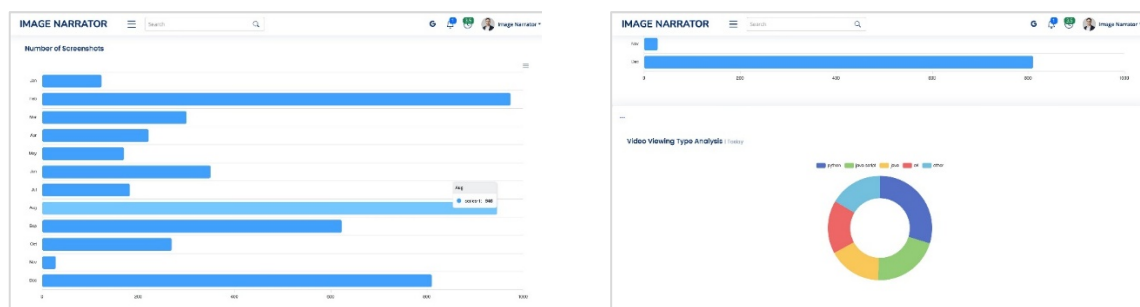


Figure 4. GenAI provides questions for practicing after learning.

4 User Testing and Results

To verify the effects of Image Narrator, some real users were tested at CNIB in Canada in 2024. 24 users have finished the experiments, including 11 males and 13 females. Among the subjects, 9 were aged 20-30 years old. 6 were 30-40 years old. 3 were 40-50 years old. 5 were 50-60 years old. 1 was aged 60-70 years old. 5 sighted people, 19 visually impaired people.

In addition to the basic information, the above users answered the questionnaire with 5 other questions.

1. How helpful is the image recognition function in assisting you in understanding the video?

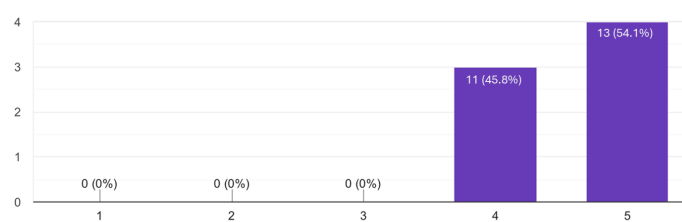


Figure 5. Results of answering Question 1 of the questionnaire after the experiment.

Rating 1-3 is 0 responses, Rating 4 is 11 responses (45.8%), and Rating 5 is 13 responses (54.1%). The mean score is 4.54, indicating a high level of agreement or satisfaction. The standard deviation is 0.50, suggesting relatively low variability in responses (see Figure 5).

2. How helpful is the exercise (generated by Image Narrator) for learning?

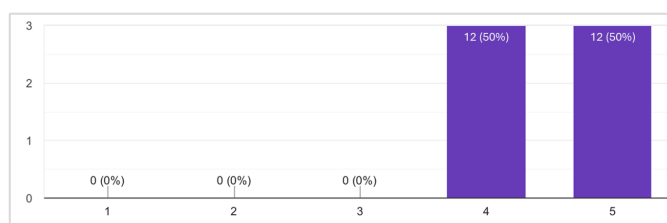


Figure 6. Results of answering Question 2 of the questionnaire after the experiment.

Rating 1-3 is 0 responses, Rating 4 is 12 responses (50%), and Rating 5 is 12 responses (50%). All respondents rated either 4 or 5, showing a highly positive evaluation. The mean score is 4.50, reflecting intense overall satisfaction or agreement. The standard deviation is 0.50, indicating low variation among participants' responses (see Figure 6).

3. The Question & Answer session is helpful for learning

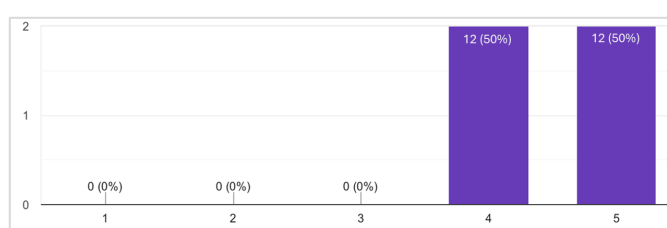


Figure 7. Results of answering Question 3 of the questionnaire after the experiment.

Rating 1-3 is 0 responses, Rating 4 is 12 responses (50%), and Rating 5 is 12 responses (50%). All respondents rated either 4 or 5, showing a highly positive evaluation. The mean score is 4.50, reflecting intense overall satisfaction or agreement. The standard deviation is 0.50, indicating low variation among participants' responses (see Figure 7).

4. Do you think the instructions are clear?

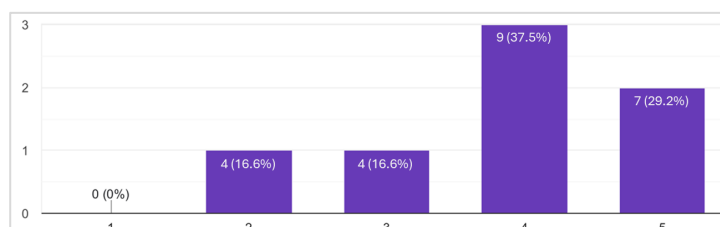


Fig. 8. Results of answering Question 4 of the questionnaire after the experiment.

Rating 1 is 0, Rating 2 is 4 responses (16.6%), Rating 3 is 4 responses (16.6%), Rating 4 is 9 responses (37.5%), and Rating 5 is 7 responses (29.2%). The mean value of the dataset is approximately 3.79. The standard deviation is approximately 1.04, which reflects a moderate spread of the data around the mean (see Figure 8).

5. Do you think Image Narrator is easy to use?

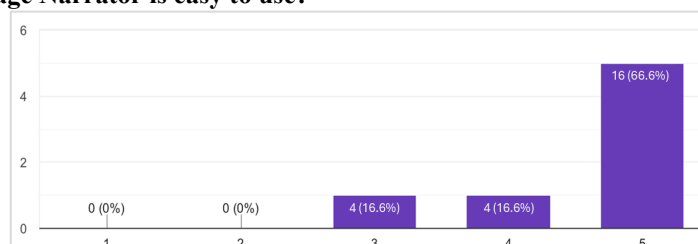


Figure 9. Results of answering Question 5 of the questionnaire after the experiment.

Rating 1-2 are 0, Rating 3 is 4 responses (16.6%), Rating 4 is 4 response2 (16.6%), and Rating 5 is 16 responses (66.6%). The mean value is approximately 4.5. This suggests that most participants selected higher response options, learning towards option 5. The standard deviation is approximately 0.76 (see Figure 9).

5 Conclusion

This study presents *Image Narrator*, an AI-enabled accessibility system that assists visually impaired learners in understanding video-based instructional content. By integrating a Chrome extension, a web platform, and generative AI-powered visual recognition, the system extracts visual information from online tutorials and converts it into accessible textual or auditory formats. User testing at CNIB showed consistently high satisfaction with the system's functions, demonstrating that AI visual narration can significantly reduce learning barriers, support independent learning, and broaden access to online STEM educational materials for visually impaired students.

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Gamified tangible interfaces with artificial intelligence to improve emotional skills in children with autism

Interfaces tangibles gamificadas con inteligencia artificial para mejorar las habilidades emocionales en niños con autismo

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Resumen. Los niños que padecen trastornos del espectro autista se distinguen por mostrar un grupo de síntomas que surgen en la primera infancia y afectan primordialmente a la comunicación y el lenguaje, el comportamiento repetitivo y la interacción social. Estos síntomas se manifiestan a lo largo de su existencia, comprometiendo y restringiendo su desempeño cotidiano. Diversas disciplinas dentro de la ciencia y la tecnología han manifestado interés en la atención a individuos con requerimientos particulares. Este trabajo expone el desarrollo de una herramienta tecnológica gamificada para mejorar las emociones en niños diagnosticados con trastorno del espectro autista. Se plantea la formulación de un concepto interactivo que reúne componentes tangibles, aplicaciones de software y elementos de gamificación. La interfaz de usuario sugerida se compone de una tarjeta lectora RFID y un conjunto de objetos equipados con etiquetas RFID para facilitar su identificación por parte del software. La herramienta fue sometida en una primera fase a evaluación por docentes de educación especial y en una segunda fase fue utilizada por tres niños, obteniendo resultados positivos en ambas etapas.

Palabras Clave: Discapacidad, enseñanza de braille, ceguera.

Summary. Children with autism spectrum disorder are distinguished by a group of symptoms that emerge in early childhood and primarily affect communication and language, repetitive behavior, and social interaction. These symptoms persist throughout their lives, compromising and restricting their daily functioning. Various disciplines within science and technology have expressed interest in addressing the needs of individuals with specific requirements. This work presents the development of a gamified technological tool to improve emotional well-being in children diagnosed with autism spectrum disorder. It proposes the formulation of an interactive concept that combines tangible components, software applications, and gamification elements. The proposed user interface consists of an RFID reader card and a set of objects equipped with RFID tags to facilitate their identification by the software. The tool was initially evaluated by special education teachers and subsequently used by three children, yielding positive results in both phases.

Keywords: Disability, Braille teaching, Blindness.

1 Introduction

En los últimos años, los entornos virtuales de aprendizaje (EVA) han experimentado una expansión

El desarrollo emocional en niños con Trastorno del Espectro Autista (TEA) representa un reto educativo y terapéutico. Estos niños suelen presentar dificultades para identificar y expresar emociones, limitando su interacción social. En años recientes, la tecnología educativa basada en inteligencia artificial (IA) ha abierto nuevas posibilidades para la personalización del aprendizaje y la retroalimentación afectiva.

Por otro lado, las interfaces tangibles de usuario (TUI) permiten que los niños aprendan a través de la manipulación física, favoreciendo la comprensión de conceptos abstractos. La herramienta tecnológica surge de la convergencia de ambas áreas: interacción tangible e IA emocional, con el propósito de crear un entorno de aprendizaje inclusivo, adaptativo y multisensorial que apoye la educación emocional de los niños con autismo.

1.1 Emotions and autism

Las emociones constituyen un elemento indispensable en la interacción humana. Los niños diagnosticados con Trastorno del Espectro Autista (TEA) manifiestan dificultades significativas en la percepción e interpretación de las emociones ajenas, así como en la respuesta emocional apropiada.

A nivel mundial, el TEA afecta aproximadamente a uno de cada cien niños (5). El TEA tiene una mayor prevalencia en hombres, con una relación de más de cuatro a uno en todo el mundo (6). Hasta un 47 % de los niños diagnosticados con TEA en 2005 también presentaban otro diagnóstico; el déficit de atención o la hiperactividad fueron los más comunes (30 %) (7). El 83 % de los niños con TEA a los ocho años tenían un diagnóstico de desarrollo concomitante, el 16 % una afección neurológica concomitante y el 10 % un diagnóstico psiquiátrico concomitante (8).

1.2 Tangible User Interfaces (TUI)

To carry out a communication between 2 or more people, there is a structure for this which is as follows: sender, as its name says, it issues the message, the next concept is the receiver, it is responsible for receiving the message from the sender, another element What is part of the structure is the message, it is defined as what you want to transmit to another person. Finally, in order for the objective of transmitting the message to be met, it is essential that there be a channel whose function is the physical medium. so that it can be transmitted.

One of the alternatives to communicate with a blind person is through the Braille language, this concept is not only and mainly a special reading and writing code. It is considered an alternative visual means of communication in conventional literacy through the sense of sight. Therefore, in the teaching and learning of this system, everything related to such mechanisms (its structure, impact on sensory and intellectual processes) [4].

Braille is defined as a system consisting of raised dots that allows blind people to read by touch, and for writing, it consists of a sheet, a strip, and a stylus. There is Braille signography for letters, numbers, punctuation marks and there is also an abbreviation system called Stenography [5].

The Braille system is of vital importance for people who are blind or visually impaired, as it provides them with access to written information and allows them to actively participate in society.

Braille is a tactile writing system designed specifically for people who are blind or visually impaired. It was invented by Louis Braille, a young blind Frenchman, in the 19th century. The Braille system is based on a series of tactile symbols or Braille characters that represent letters, numbers, punctuation marks and other symbols, allowing blind people to read and write independently.

Braille has been indispensable throughout history for people with visual impairments, as a necessary tool for communication, which goes beyond being a writing technique for the blind.

Thanks to this system of representation of alphabetic and numerical signs that uses dots as musical, mathematical, and scientific symbols, blind people can learn, educate themselves, and connect with their environment from an equitable and autonomous perspective.

1.3 Inclusive Technologies

ICTs are tools that promote equity, relevance, and inclusion in school learning environments and foster the development of skills such as reasoning, interpreting, arguing, proposing, modeling, decision-making, and problem-solving, among others. Therefore, their use as learning mediators, even for people with disabilities, is essential to achieving the goal of educational quality [6].

In [7] it is mentioned that electronic devices are commercially distributed that allow people with visual disabilities to read digital content translated into Braille, such as the BraiBook, which is a portable device that has an 8-point Braille cell based on the principle of piezoelectric materials and an audio system for greater ease in reading digital content, however, this is a personal device and does not allow interaction between teachers and students as a teaching tool in training environments, in addition there are no documented methodologies that use this type of devices for the training of people with visual disabilities.

Using ICTs can help overcome learning barriers related to disability, poverty, distance and geographical location [8] [9]. They can also help provide students, regardless of their needs, with the learning opportunities they need[10] .

In [11] it is stated that ICT can help create a more inclusive learning environment by providing all students with access to educational information and resources.

It is essential to recognize the possibilities offered by ICT according to a series of authors[12] [13] [14] to generate processes that make quality learning possible for all students, they are diverse since they promote communication between all participants in the training action, break the barriers of space and time allowing integration and decontextualized and ubiquitous learning, offer the opportunity to access high quality materials from remote sites, promote flexible and ubiquitous learning, facilitate access to information, delocalize information and facilitate access to it regardless of the economic conditions of the place of residence, and present

the information in the symbolic system most appropriate to the cognitive and physiological characteristics of the person.

The main objective of this work is to design an electronic prototype as a technological teaching tool that supports the teaching-learning process of Braille for reading and writing for children with visual impairments. The teaching tool promotes inclusion and inclusive education by providing an innovative way to teach and learn Braille.

The technological tool was developed in the laboratory of the Research and Development Group for Inclusive Technologies and Educational Innovation (GIDTIITEC, by its Spanish initials), at the Autonomous University of Baja California Sur (UABCS, for its Spanish initials).

2 Methodology

For the development of the project, a methodology based on Design Thinking and Agile Development was used [15]. This methodology balances user-centered design, rapid iteration, and continuous validation. To achieve the project's objectives, four stages were established, as shown in Figure 1.

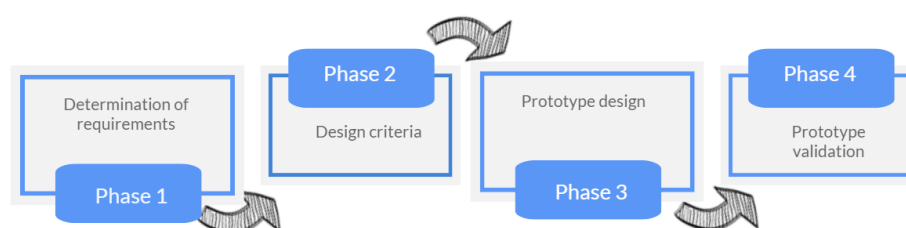


Figure 2. Project stages.

2.1 Determination of requirements

Para determinar los requisitos de la herramienta se llevaron a cabo reuniones con expertos en educación especial y con docentes de educación primaria. A partir de la información recopilada mediante cuestionarios y entrevistas, se establecieron los requisitos para desarrollar un sistema que diera solución al problema identificado.

Durante las reuniones de trabajo, se determinó que, para que el prototipo funcionara, sería necesario integrar los requisitos de hardware y software, como se muestra en la Figura 2.

Favorecer el desarrollo de la inteligencia emocional y las habilidades socioemocionales en niños con autismo a través de la interacción con interfaces tangibles que promueven la reconocimiento, expresión y regulación de emociones.

Asociar expresiones faciales con emociones básicas (alegría, tristeza, enojo, miedo, sorpresa, calma).

Desarrollar la empatía mediante historias interactivas con personajes virtuales.

Fomentar la autorregulación emocional mediante dinámicas de respiración y juego guiado.

Potenciar la motricidad fina y la atención sostenida a través de la manipulación de objetos tangibles.

2.2 Design criteria

Based on the analysis of the collected information and the hardware and software requirements, design criteria were established to be considered during the development of the electronic prototype as a learning tool. In the working meetings, strategies for learning the Braille system were analyzed, as well as the requirements and fundamental characteristics of the system's elements.

The reading and writing process in people with visual impairments is developed using the Braille system, which is adapted to the characteristics of the sense of touch (Álvarez, Sumba, & Arteaga, 2020).

There are various strategies to facilitate learning the Braille system, especially for children with visual impairments. These strategies seek to integrate the tactile, cognitive, and pedagogical aspects of the teaching-learning process to make learning Braille effective and engaging.

It is essential to consider a series of design criteria to ensure that the device is accessible, functional, educational, and suitable for children with visual impairments. The main design criteria to consider:

1. Touch and auditory interface: The design should focus on providing an accessible experience, where users can interact through touch and hearing (auditory feedback or spoken instructions).

2. Ergonomics: The device should be comfortable and easy for children to use, considering the size of their hands and ease of access to buttons or touch sensors.
3. Ease of use: The prototype should offer a simple and intuitive experience, especially for young users, avoiding complex interactions.
4. Adaptive design: The prototype should be suitable for different levels of Braille knowledge, allowing both beginners and more advanced users to use it effectively.
5. Clear and understandable interface language: Auditory instructions and any feedback provided should be clear and appropriate to the child's cognitive level.
6. Progress tracking: Implement functionality that allows the software to monitor and record the user's learning progress, offering suggestions or adaptations as the child improves.
7. Affordability: Components used in the design must be accessible and low-cost to ensure that the final product is affordable for mass production and can reach schools and families without prohibitive costs.

2.3 Prototype design

The prototype design was divided into two fundamental parts: hardware and software, which interact harmoniously. The hardware component of the prototype focuses on creating a physical platform that allows children to interact with the braille system through tactile exploration and haptic feedback. The software component of the prototype is responsible for processing input from the hardware, managing the interaction logic, and providing feedback to the user.

2.3.1 Hardware design

For the hardware design, it was necessary to use various electronic components that provide the device's functionality. The components required for operation are listed below, and the component connection diagram is shown in Figure 3.

1. Raspberry Pi programming board: this technology has its own operating system, which allows the user to program the GPIO ports, as well as design software to monitor the execution process.
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6. Resistors: used to control the flow of energy to protect various electronic components.
7. Buzzer: It is an alarm to notify the user if he or she is doing the exercises correctly for learning Braille.
8. Battery: to power the circuit.
9. Switch: so that the prototype can be turned on and off.

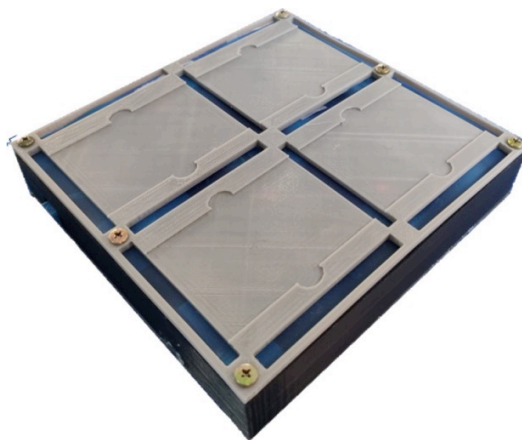


Figure 3. Physical design of the electronic components container of the RFID reader board.

2.3.2 Software design

Python was used for software development. Python was also used for programming the Raspberry Pi's GPIO ports, along with the RPi.GPIO library for configuring and controlling the GPIO pins.

Software plays a key role in managing interaction logic and providing appropriate feedback to users, as well as making the hardware work properly.

The software functionality is broken down into:

- a) Input processing. The software is responsible for receiving and processing signals sent by hardware input devices, such as buttons or touch sensors.
- b) Control of output components. After processing the inputs, the software controls the device's output, including auditory feedback by playing a sound or a spoken message through speakers, such as pronouncing the character or word the child is writing or reading in braille.
- c) Learning flow management. The software is responsible for guiding the user through the different stages of learning the Braille system. This includes real-time assessment while the child interacts with the device. The software can evaluate whether the answers are correct or incorrect, providing immediate feedback.

2.4 Prototype validation

During the validation phase, the prototype's functionality was tested. A validation and learning recognition instrument consisting of one session was applied, the objective of which was to evaluate Braille reading ability at a total of 10 levels.

3 Results

El juego se compone de niveles o misiones, cada uno centrado en una emoción específica. La experiencia se desarrolla en cuatro fases principales:

3.1 Fase 1. Exploración emocional

En la primera fase del juego el niño inicia su interacción con la herramienta a través de la manipulación de los bloques tangibles que representan diferentes emociones básicas, como alegría, tristeza, enojo, miedo, sorpresa y calma. Cada bloque cuenta con características sensoriales distintivas —color, textura y símbolo— que facilitan su identificación y estimulación táctil. Al colocar uno de los bloques sobre la base lectora, el sistema lo reconoce mediante tecnología RFID y activa en la pantalla una escena interactiva protagonizada por el avatar del juego, quien introduce al niño en una situación cotidiana relacionada con una emoción específica. Estas escenas presentan narrativas simples y visualmente claras, por ejemplo: “un amigo comparte un juguete” o “un niño pierde su pelota”, diseñadas para facilitar la comprensión y conexión con las experiencias emocionales del día a día.

Durante esta fase, la inteligencia artificial del sistema analiza las elecciones del niño y adapta las situaciones de acuerdo con su nivel de comprensión emocional. Si el niño selecciona un bloque incorrecto, el avatar ofrece pistas visuales o verbales que lo orientan hacia la respuesta adecuada, reforzando el proceso de aprendizaje sin generar frustración. El objetivo principal de esta etapa es que el niño reconozca y asocie las emociones básicas con diferentes contextos sociales, utilizando tanto la percepción visual como la experiencia táctil. A través de esta dinámica, se promueve el desarrollo de la conciencia emocional y se sientan las bases para las siguientes fases del juego, centradas en la expresión y la regulación de emociones.

3.2 Fase 2. Expresión emocional

En la segunda fase el niño avanza hacia la identificación activa y la comunicación de las emociones reconocidas en la fase anterior. En este nivel, la herramienta invita al usuario a expresar las emociones a través de múltiples modalidades sensoriales y tangibles. La dinámica inicia cuando el avatar del juego plantea una situación emocional —por ejemplo, “tu amigo te invita a jugar” o “te quitan un juguete que te gusta”— y solicita al niño que exprese cómo se sentiría en esa circunstancia. Para ello, el participante puede utilizar tarjetas tangibles con expresiones faciales, cubos de colores asociados a cada emoción o incluso realizar gestos faciales frente a la

cámara del dispositivo, los cuales son interpretados mediante inteligencia artificial con reconocimiento facial y análisis de microexpresiones.

El sistema analiza la respuesta del niño en tiempo real, ofreciendo retroalimentación positiva y adaptativa. Si la emoción expresada coincide con la esperada, el avatar celebra con una animación o sonido agradable; si no, ofrece una breve explicación o ejemplo visual que ayude a comprender mejor la emoción representada. Esta fase tiene como propósito fortalecer la capacidad de comunicación emocional, promoviendo que el niño no solo identifique lo que siente, sino que aprenda a manifestarlo de manera apropiada y comprensible.

Además, la IA del sistema ajusta progresivamente el nivel de dificultad, variando la complejidad de las situaciones o combinando emociones secundarias, como frustración o sorpresa, a medida que el niño demuestra avances. Esta personalización permite que la experiencia sea inclusiva y empática, respetando el ritmo individual de aprendizaje de cada usuario. De esta manera, la fase de expresión emocional se convierte en un espacio lúdico-terapéutico que potencia la autoconfianza, la empatía y la conexión social a través del juego tangible y la tecnología inteligente.

3.3 Fase 3. Regulación emocional

La tercera fase representa el nivel más avanzado de la herramienta y tiene como objetivo que el niño aprenda a manejar y modular sus emociones ante distintas situaciones sociales o personales. En esta etapa, el sistema propone escenarios dinámicos y más complejos en los que las emociones se entrelazan —por ejemplo, “un amigo accidentalmente rompe tu juguete favorito” o “ganas un juego después de varios intentos”—. A partir de estos contextos, el niño debe seleccionar entre los bloques tangibles de estrategias emocionales (por ejemplo: respirar, pedir ayuda, esperar, expresar con palabras), identificados por símbolos y texturas particulares. Al colocar uno de estos bloques en la base lectora, la herramienta activa una secuencia animada donde el avatar modela la estrategia elegida, mostrando las posibles consecuencias de su uso.

Durante el proceso, la inteligencia artificial analiza el patrón de decisiones del niño, identificando tendencias impulsivas o reacciones repetitivas, y adapta las respuestas del avatar para ofrecer apoyo emocional personalizado. Por ejemplo, si el sistema detecta que el niño tiende a elegir respuestas de enojo ante la frustración, la IA introduce un módulo de práctica guiada con ejercicios de respiración o empatía visual, reforzando alternativas más equilibradas. Asimismo, mediante el reconocimiento de voz, el sistema evalúa el tono emocional del niño cuando se le invita a verbalizar su respuesta, ayudándole a tomar conciencia de su estado emocional y a autorregular su conducta de manera constructiva.

Esta fase concluye con una retroalimentación global del progreso emocional del niño, donde se muestran sus avances en reconocimiento, expresión y regulación de emociones a través de un recorrido visual gamificado. El objetivo final es fomentar el autoconocimiento emocional y la autorregulación adaptativa, fortaleciendo la autonomía y las habilidades sociales del niño. Gracias a la integración de interfaces tangibles e inteligencia artificial, la herramienta convierte el aprendizaje emocional en una experiencia interactiva, empática y significativa, contribuyendo al bienestar emocional y a la inclusión educativa de niños con autismo.

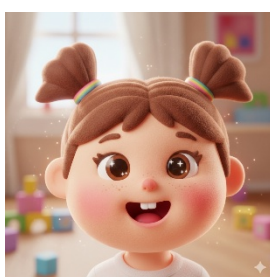


Figure 4. Design of the housing for the placement of the final circuit.



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Figure 4. Design of the housing for the placement of the final circuit.

4 Conclusions

The process of inclusion in students with disabilities is constituted as an emerging field that requires a global change in culture and a greater involvement of all the actors involved [17].

The development of the electronic prototype as a teaching tool represents a significant advance in supporting the teaching and learning process of Braille for children with visual impairments. Through the design and implementation of this technology, the feasibility of integrating accessible and interactive solutions that contribute to strengthening both Braille reading and writing skills from an early age has been demonstrated.

The results obtained throughout the design process show that the use of technological devices can promote student autonomy, motivate learning, and facilitate the work of teachers or tutors in the educational process. Furthermore, the didactic approach incorporated in the prototype allows for dynamic adaptation of content, providing a personalized experience tailored to the specific needs of users.

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Educational Electronic Prototype to Support the Learning of Braille Prototipo electrónico educativo para apoyar el aprendizaje del braille

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Summary. The process of inclusion is dynamic and ongoing, requiring ongoing commitment from all members of society. For blind people to be educated and integrated into society, braille is crucial. Like sighted individuals, it enables them to access reading and writing, engage in formal education, find work, and appreciate literature and culture. For those who are blind or visually challenged, Braille is still an essential tool despite technological advancements. Designing a technological teaching tool that supports the teaching-learning process of the Braille language in the reading and writing modality for children with visual disabilities is the primary goal of this project.

Keywords: Disability, Braille teaching, Blindness

Resumen. El proceso de inclusión es dinámico y continuo, y requiere el compromiso constante de todos los miembros de la sociedad. Para que las personas ciegas se eduquen e integren en la sociedad, el braille es crucial. Al igual que para las personas videntes, les permite acceder a la lectura y la escritura, participar en la educación formal, encontrar trabajo y apreciar la literatura y la cultura. Para las personas ciegas o con discapacidad visual, el braille sigue siendo una herramienta esencial a pesar de los avances tecnológicos. El objetivo principal de este proyecto es diseñar una herramienta didáctica tecnológica que apoye el proceso de enseñanza-aprendizaje del lenguaje braille en la modalidad de lectura y escritura para niños con discapacidad visual.

Palabras Clave: Discapacidad, enseñanza de braille, ceguera.

1 Introduction

Disability, according to the World Health Organization (WHO), is a generic word that encompasses impairments, physical limitations of an activity, and constraints on participation. The activity's physical constraints make it difficult to complete a task, while participation limitations make it impossible to interact in crucial circumstances [1].

Additionally, according to the WHO, a visual handicap is a constraint in doing daily chores, which consequently impacts one's quality of life and opportunities for engagement with others [1].

1.1 Visual disability

The integration of individuals with visual impairments is a fundamental component of equitable opportunities and rights within society. Establishing an accessible environment and fostering inclusion are vital measures for achieving a more fair society that honors diversity.

Visual impairment is characterized by visual acuity and the extent of the visual field. Visual impairment is discussed when there is a substantial reduction in visual acuity despite the use of corrective lenses, or a marked decrease in the visual field. Visual acuity is the capacity of an individual to distinctly discern the form and contours of objects at a specific distance. The visual field denotes the area of space observable by an individual without the necessity of head or eye movement. An individual with typical vision possesses a horizontal visual field of 150° and a vertical visual field of 140°.

The World Health Organization categorizes visual function into four tiers: normal vision, moderate visual impairment, severe visual impairment, and blindness.

Moderate vision difficulty and severe visual impairment are categorized as low vision, whereas low vision combined with blindness constitutes the broader classification of visual impairment [2].

In Mexico, data from INEGI indicates that 7 million 650 thousand individuals reported having a disability, constituting 6.4% of the total population, with 1 million 561 thousand individuals experiencing visual impairment. Among individuals with visual impairments, 63.5% do not utilize any form of technological assistance, while merely 4.6% employ the Braille system [3].

1.2 Braille system

To carry out a communication between 2 or more people, there is a structure for this which is as follows: sender, as its name says, it issues the message, the next concept is the receiver, it is responsible for receiving the message from the sender, another element What is part of the structure is the message, it is defined as what you want to transmit to another person. Finally, in order for the objective of transmitting the message to be met, it is essential that there be a channel whose function is the physical medium. so that it can be transmitted.

One of the alternatives to communicate with a blind person is through the Braille language, this concept is not only and mainly a special reading and writing code. It is considered an alternative visual means of communication in conventional literacy through the sense of sight. Therefore, in the teaching and learning of this system, everything related to such mechanisms (its structure, impact on sensory and intellectual processes) [4].

Braille is defined as a system consisting of raised dots that allows blind people to read by touch, and for writing, it consists of a sheet, a strip, and a stylus. There is Braille signography for letters, numbers, punctuation marks and there is also an abbreviation system called Stenography [5].

The Braille system is of vital importance for people who are blind or visually impaired, as it provides them with access to written information and allows them to actively participate in society.

Braille is a tactile writing system designed specifically for people who are blind or visually impaired. It was invented by Louis Braille, a young blind Frenchman, in the 19th century. The Braille system is based on a series of tactile symbols or Braille characters that represent letters, numbers, punctuation marks and other symbols, allowing blind people to read and write independently.

Braille has been indispensable throughout history for people with visual impairments, as a necessary tool for communication, which goes beyond being a writing technique for the blind.

Thanks to this system of representation of alphabetic and numerical signs that uses dots as musical, mathematical, and scientific symbols, blind people can learn, educate themselves, and connect with their environment from an equitable and autonomous perspective.

1.3 Educational technologies and inclusion

ICTs are tools that promote equity, relevance, and inclusion in school learning environments and foster the development of skills such as reasoning, interpreting, arguing, proposing, modeling, decision-making, and problem-solving, among others. Therefore, their use as learning mediators, even for people with disabilities, is essential to achieving the goal of educational quality [6].

In [7] it is mentioned that electronic devices are commercially distributed that allow people with visual disabilities to read digital content translated into Braille, such as the BraiBook, which is a portable device that has an 8-point Braille cell based on the principle of piezoelectric materials and an audio system for greater ease in reading digital content, however, this is a personal device and does not allow interaction between teachers and students as a teaching tool in training environments, in addition there are no documented methodologies that use this type of devices for the training of people with visual disabilities.

Using ICTs can help overcome learning barriers related to disability, poverty, distance and geographical location [8] [9]. They can also help provide students, regardless of their needs, with the learning opportunities they need [10].

In [11] it is stated that ICT can help create a more inclusive learning environment by providing all students with access to educational information and resources.

It is essential to recognize the possibilities offered by ICT according to a series of authors [12] [13] [14] to generate processes that make quality learning possible for all students, they are diverse since they promote communication between all participants in the training action, break the barriers of space and time allowing integration and decontextualized and ubiquitous learning, offer the opportunity to access high quality materials from remote sites, promote flexible and ubiquitous learning, facilitate access to information, delocalize information and facilitate access to it regardless of the economic conditions of the place of residence, and present the information in the symbolic system most appropriate to the cognitive and physiological characteristics of the person.

The main objective of this work is to design an electronic prototype as a technological teaching tool that supports the teaching-learning process of Braille for reading and writing for children with visual impairments. The teaching tool promotes inclusion and inclusive education by providing an innovative way to teach and learn Braille.

The technological tool was developed in the laboratory of the Research and Development Group for Inclusive Technologies and Educational Innovation (GIDTIITEC, by its Spanish initials), at the Autonomous University of Baja California Sur (UABCS, for its Spanish initials).

2 Methodology

For the development of the project, a methodology based on Design Thinking and Agile Development was used [15]. This methodology balances user-centered design, rapid iteration, and continuous validation. To achieve the project's objectives, four stages were established, as shown in Figure 1.

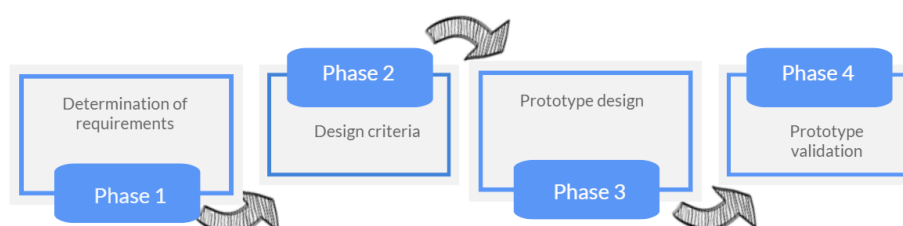


Figure 3. Project stages.

2.1 Determination of requirements

To determine the requirements for the electronic prototype, we worked in collaboration with experts in the area of special education, as well as with elementary education teachers. Based on the information gathered through questionnaires and interviews, the requirements for developing a system that provides a solution to the identified problem were established. During the working meetings, it was determined that for the prototype to function, it would be necessary to integrate hardware and software requirements, as shown in Figure 2.

Hardware requirements include a small device size and a touch interface for both writing and reading. Software requirements include communication with the hardware, the use of sounds, and teaching methodology.

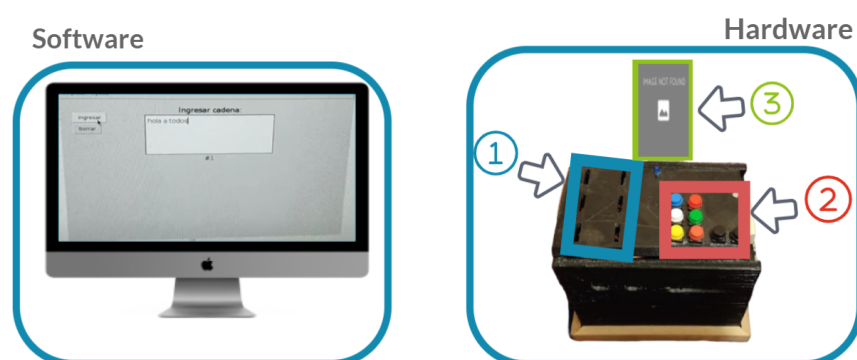


Fig. 2. Prototype hardware and software requirements.

2.2 Design criteria

Based on the analysis of the collected information and the hardware and software requirements, design criteria were established to be considered during the development of the electronic prototype as a learning tool. In the working meetings, strategies for learning the Braille system were analyzed, as well as the requirements and fundamental characteristics of the system's elements.

The reading and writing process in people with visual impairments is developed using the Braille system, which is adapted to the characteristics of the sense of touch (Álvarez, Sumba, & Arteaga, 2020).

There are various strategies to facilitate learning the Braille system, especially for children with visual impairments. These strategies seek to integrate the tactile, cognitive, and pedagogical aspects of the teaching-learning process to make learning Braille effective and engaging.

It is essential to consider a series of design criteria to ensure that the device is accessible, functional, educational, and suitable for children with visual impairments. The main design criteria to consider:

Touch and auditory interface: The design should focus on providing an accessible experience, where users can interact through touch and hearing (auditory feedback or spoken instructions).

Ergonomics: The device should be comfortable and easy for children to use, considering the size of their hands and ease of access to buttons or touch sensors.

Ease of use: The prototype should offer a simple and intuitive experience, especially for young users, avoiding complex interactions.

Adaptive design: The prototype should be suitable for different levels of Braille knowledge, allowing both beginners and more advanced users to use it effectively.

Clear and understandable interface language: Auditory instructions and any feedback provided should be clear and appropriate to the child's cognitive level.

Progress tracking: Implement functionality that allows the software to monitor and record the user's learning progress, offering suggestions or adaptations as the child improves.

Affordability: Components used in the design must be accessible and low-cost to ensure that the final product is affordable for mass production and can reach schools and families without prohibitive costs.

2.3 Prototype design

The prototype design was divided into two fundamental parts: hardware and software, which interact harmoniously. The hardware component of the prototype focuses on creating a physical platform that allows children to interact with the braille system through tactile exploration and haptic feedback. The software component of the prototype is responsible for processing input from the hardware, managing the interaction logic, and providing feedback to the user.

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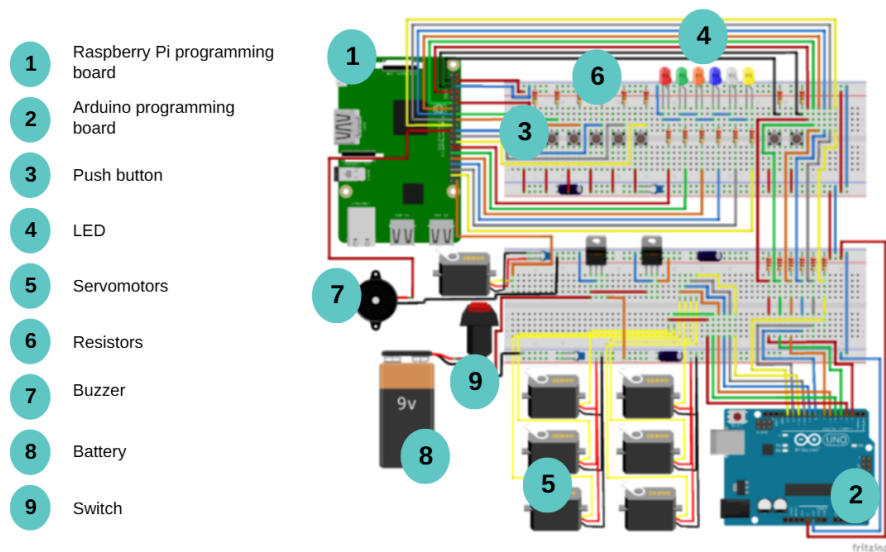


Figure 3. Connection diagram of hardware components.

2.3.2 Software design

Python was used for software development. Python was also used for programming the Raspberry Pi's GPIO ports, along with the RPi.GPIO library for configuring and controlling the GPIO pins.

Software plays a key role in managing interaction logic and providing appropriate feedback to users, as well as making the hardware work properly.

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2.4 Prototype validation

During the validation phase, the prototype's functionality was tested. A validation and learning recognition instrument consisting of one session was applied, the objective of which was to evaluate Braille reading ability at a total of 10 levels.

3 Results

Tinkercad was used for the design, CAD modeling, and prototyping of the housing. The dimensions of the housing, which housed the final circuit, were 18 cm long by 15 cm high by 12.5 cm wide. Figure 4 shows the housing components, as well as the 3D printer used to make it.

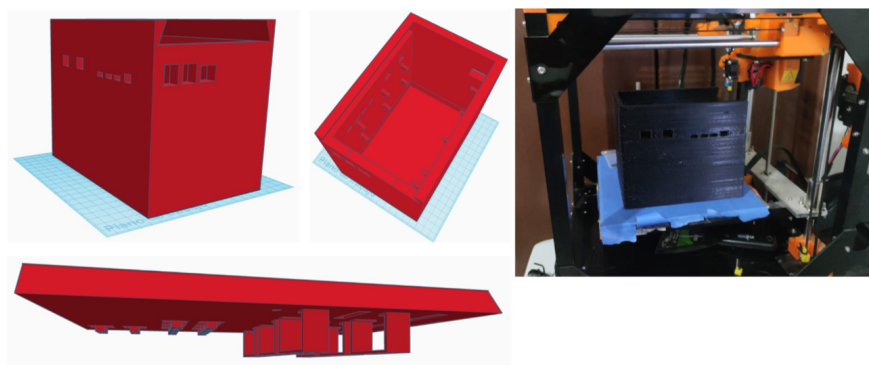


Figure 4. Design of the housing for the placement of the final circuit.

Tests were conducted to verify the prototype's proper functioning. The interaction between the Raspberry Pi and Arduino technologies and the software was verified. The synchronization of both elements was reviewed, with tests of the Braille reading and writing process involving a special education specialist and a visually impaired person, as shown in Figure 5.

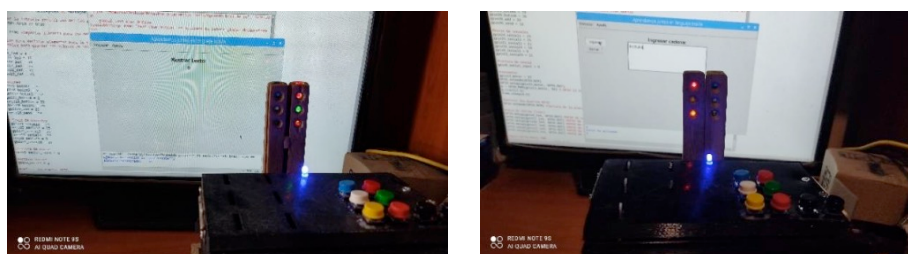


Figure 5. Tests of Braille reading and writing performance.

The tests carried out were: response time when writing, response time when reading, system validation when numbers were entered, and validation if it detects all lowercase letters of the alphabet. The graph in Figure 6 shows the response time for each of the tests performed, where a maximum response time of 5 seconds can be observed in the writing mode.

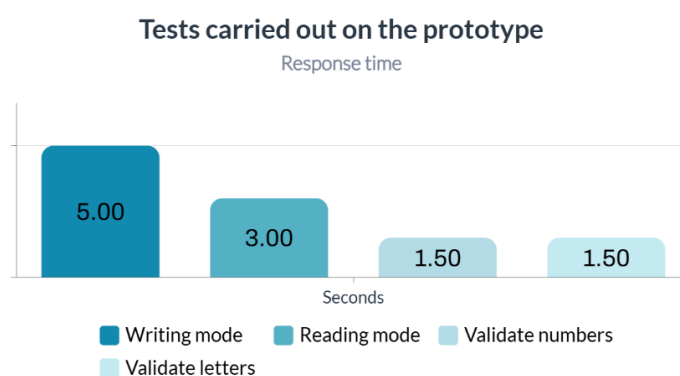


Figure 6. Prototype response time testing.

The graph in Figure 7 shows the percentages of correct answers for each of the tests performed.

Once the prototype tests were completed, an analysis was carried out to propose improvements, among which were identified: optimizing the algorithm and response time, reducing the size of the box and simplifying the circuit.

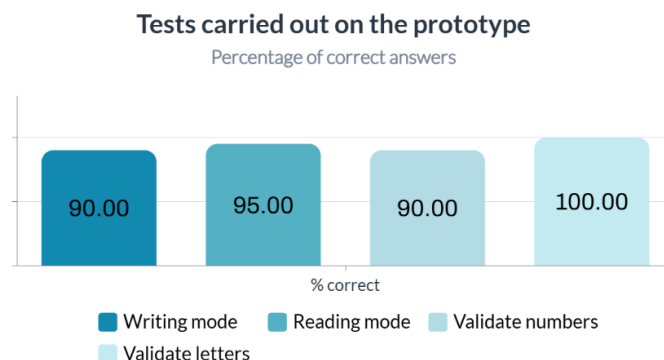


Figure 7. Testing for correct prototype responses.

4 Conclusions

The process of inclusion in students with disabilities is constituted as an emerging field that requires a global change in culture and a greater involvement of all the actors involved [17].

The development of the electronic prototype as a teaching tool represents a significant advance in supporting the teaching and learning process of Braille for children with visual impairments. Through the design and implementation of this technology, the feasibility of integrating accessible and interactive solutions that contribute to strengthening both Braille reading and writing skills from an early age has been demonstrated.

The results obtained throughout the design process show that the use of technological devices can promote student autonomy, motivate learning, and facilitate the work of teachers or tutors in the educational process. Furthermore, the didactic approach incorporated in the prototype allows for dynamic adaptation of content, providing a personalized experience tailored to the specific needs of users.

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Su objetivo principal es la divulgación del quehacer académico de la investigación y las prácticas docentes inmersas en la informática y la computación, así como las diversas vertientes de la tecnología educativa desde la perspectiva de la informática y el cómputo, en la que participan investigadores y académicos latinoamericanos. Enfatiza y declara expresamente la publicación de artículos de investigaciones con exigencia en la originalidad con carácter inédito y arbitrado.

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