Design and usability of an avatar-based learning program to support diabetes education – Quality improvement study in Colombia

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Abbreviations: Avatar-Based LEarning for Diabetes Optimal Control (ABLEDOC), People with diabetes (PWD), Type 1 Diabetes (T1D), Type 2 Diabetes (T2D), Virtual Reality (VR), Quality Improvement (QI).

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Abstract

***Background**: This quality improvement study, entitled Avatar-Based LEarning for Diabetes Optimal Control (ABLEDOC), explored the feasibility of delivering an educational programme to people with diabetes in Colombia. The aim was to discover how this approach could be used to improve awareness and understanding of the condition, the effects of treatment, and strategies for effective management of blood-glucose control.*

***Methods**: Individuals with diabetes were recruited by Colombian endocrinologists to a human-centred study to co-design the educational programme, using the Double Diamond model. Participants contributed to two phases. The first phase focused on gathering unmet educational needs, and choice of curriculum. Three prototypes were developed as a result. During Phase Two, a different group of participants engaged with the programme for several weeks, before reporting back.*

***Results:** Thirty-six participants completed a web survey during Phase One, and five were also interviewed by telephone. The majority (33 of 36, 91%) were receptive to the prospect of educational interventions, and ranked the chosen topic of hypoglycemia highly. In Phase Two, the three prototypes were tested by seventeen participants, ten of which also gave feedback in focus groups. The response was overwhelmingly positive, with 16 of 17 (94%) stating they would use a program like this again. The 3D version was the most highly rated.*

Conclusion: *Immersive, avatar-based programmes, delivered via smartphone, have the potential to deliver educational information that is trusted, engaging and useful. Future work includes expansion of the curriculum, evaluation with a larger group, and exploration of the prospective role of artificial intelligence in personalising this form of educational intervention.*

Introduction

Colombia has the second highest incidence of diabetes of any country in South and Central America, according to the International Diabetes Federation[1]. Estimates suggest that there were 3.4 million adults known to have the condition in 2021, with a further 1.2 million living with it undiagnosed. Prevalence of the condition is increasing, due to sedentary lifestyles, societal dietary patterns, low educational levels, ageing of the population and the high rate of urbanisation[2]. The risk of developing long-term complications associated with diabetes can be reduced by optimising glycemia[3], but this requires knowledge of a variety of factors including blood glucose dynamics, medication, and technology. Hence, there is a potential appetite for engaging educational interventions that deliver the skills needed to improve control safely, as evidenced by recent research[4]. Education has also been linked to multiple key drivers of quality improvement (QI) for people with diabetes (PWD)[5,6], and there is evidence that some QI strategies can improve outcomes for socially disadvantaged groups[7.] Hispanic populations are among those that are more likely to have higher levels of acute complications, less optimal glycemia, and less use of technology[8]. This could result from language or cultural differences, lack of financial resources, or distance from care providers[9]. Solutions must therefore include equitable access to health care and education[8].

Emerging technologies, such as mobile games and virtual reality (VR), are proving to be popular and effective educational tools that can overcome language, literacy and numeracy barriers, and stimulate new behaviours[10]. The interactive, visual content can improve recall and retention of information[11]. Avatar-based technology can have a positive effect on knowledge and self-care among people with chronic conditions, such as diabetes[12]. Such technology can be used to create easy-to-understand, interactive healthcare information in 3D that individuals can view on smartphones, iPads or VR headsets, to learn how to self-manage their health. The content is prescribed by clinicians, and can be viewed both in the clinic and at home. This approach has potential to provide timely, trusted information in a country like Colombia, where 85% of the population live in areas covered by 3G/4G and 63% own smartphones[13], at a time when mobile phones are transforming the landscape of diabetes care around the world[14].

Cognitant Group Ltd (Oxford, UK) was the lead partner in the ABLEDOC project, which brought together a multidisciplinary team of academics, clinicians, and industry professionals from the UK and Colombia to explore the feasibility of an avatar-based educational programme for PWD in Colombia. VR-education is safe and well-liked among clinical diabetes staff[15], but this is the first study of its use with PWD in Colombia, according to a Pubmed search. The aim of this QI study was to work collaboratively with a small group of Colombian clinicians and PWD, using a structured method to fully understand the local problems

and current educational practices, in order to discover how such an educational intervention might improve awareness and understanding of the condition, the effects of treatment, and strategies for effective self-management. A pilot programme for PWD in Colombia was subsequently developed, delivered and evaluated, focusing on an identified intervention from the design study.

Methods

The human-centred Double Diamond methodology[16] was used to understand the local problems and current educational practices for diabetes in Colombia. This process comprises four steps: *Discover, Define, Develop* and *Deliver.* The steps are separated into two diamonds, each of which has a divergent phase, to expand the problem space, then a convergent phase that narrows down the options (see Fig. 1). The first diamond allows researchers to *discover* the problem from the perspective of those most affected by it, instead of relying on assumptions. The resulting insights are used to *define* the challenge. The second diamond encourages co-creation by *developing* different solutions to the clearly defined problem. *Delivery* involves testing the solutions with a range of people to improve the final result. The steps were instantiated within the ABLEDOC project as follows:

1. **Discover** the educational experience and needs of different demographic groups, as well as key trends that could inform the curriculum, by working with expert clinicians and patient associations in Colombia.

2. **Define** the pilot topic of choice, target audience and full curriculum.
3. **Develop** multiple prototypes of an avatar-based programme for PWD in Colombia, focusing on one educational intervention.
4. **Deliver** the prototypes to a small cohort of participants to evaluate the approach and determine the preferred visual delivery method.

The methodology for each of these phases is defined below. The version described here includes modifications due to the *Covid-19* lockdown in Colombia, which occurred during the study period. All of the user interactions that were originally designed to be face-to-face were moved online as a consequence.

Discover

The discovery phase was divided into two parts: desk research and a user study.

1. Desk Research

The purpose of the desk research was to assimilate information on three aspects of the experience of PWD in Colombia. These were: unmet educational needs; pilot topic of choice; health information access. The team collected information about which materials are typically received and at what point in the patient journey, in order to learn where the intervention could fit into a traditional educational programme, and how to disseminate it effectively.

The study team included two endocrinologists from the Hospital Universitario San Ignacio (HUSI) (Bogotá, Colombia), and was supported by an external advisory board of clinicians and academics. Key learning needs and a pilot topic of choice were identified from the HUSI clinicians' observations and assumptions. These were reviewed by the advisory board and used to develop a draft educational curriculum, for validation in the Phase One User Study.

2. Phase One User Study

The purpose of this phase was to identify any issues associated with the choice of curriculum, its presentation and the target group. The study encompassed a web survey and interviews to obtain a deeper understanding of health information access and topics of interest from the participants' perspectives.

The Phase One recruitment target was thirty-five participants from the HUSI, all of which were required to provide verbal and written informed consent. Thirty of the participants were invited to complete a 30-minute online survey (group 1), and 5 were asked to participate in a 1:1, 30-minute telephone interview, conducted by a clinician (group 2). Inclusion criteria were as follows: Adult participants aged 18-65, Type 1 Diabetes (T1D) or Type 2 Diabetes (T2D) and a disease duration >1 year. Additional inclusion criteria for group 2 include treatment with a prandial glucose regulator, insulin, and/or a sulfonylurea. All participants were required to be regular smartphone users with access to an iPhone or an Android phone.

Interview data were collected via audio-recording and note-taking. The recordings were subsequently transcribed into Spanish, then translated to English for analysis. The protocols for this and the Phase Two user study were approved by the research and institutional ethics committee of the HUSI.

Define

The results of the Discover phase were used to define the pilot topic of choice, target audience and final syllabus.

The survey data allowed investigators to review trends in unmet learning needs, and factors that most affect the participants' quality of life, according to individual characteristics, in order to refine the curriculum requirements in relation to the pilot topic.

The interview data provided a more complete picture of in-depth personal experiences and patient journeys. This was used to construct personas to give a tangible picture of the lives of the target audience. For example: what they think; how they behave; their wants and needs, along with their fears or frustrations; their influencers and environment.

The syllabus was characterized in terms of learning objectives and educational approach.

Develop

The next step was software development. The approved curriculum was transformed into an evidence-based storyboard to deliver engaging content, designed to promote health behaviour changes that the participants would be likely to adopt. The software was then created using 3D models, visual animations and text prompts, to aid understanding and recall.

Three learning modules were created, to allow users to choose which mode of visual presentation was most effective for their needs. The content was delivered via the *Healthinote* app (Cognitant, Oxford, UK). The workflow through which information is disseminated using Healthinote is shown in Fig. 2. Clinicians prescribe educational content, based on individual needs, via a QR code or link in an SMS message. Users can then engage with the tailored information by viewing the VR content on their smartphones.

Deliver

The purpose of the Phase Two User Study was to assess the preferred mode of presentation, satisfaction with modules, increase in knowledge and confidence to self-manage. The recruitment target was 12-15 participants, and inclusion criteria were the same as Phase One Group 2. Participants were given the opportunity to engage with the programme over a period of several

246 weeks, before reporting back via a series of 3-hour online focus groups. All
247 participants were asked to complete a post-study questionnaire.
248
249 At the start of the study, participants received an SMS text with written
250 instructions explaining how to access the programme. They were also supplied
251 with a Google Cardboard headset[17], to view 3D content. The HUSI team
252 created videos describing how to download the Healthinote app and how to
253 use the headset, and Cognitant translated its instruction video to Spanish.
254
255 After a minimum of four weeks, participants were invited to join a focus group.
256 Opinions were sought on the choice of topic, method of presentation, use of
257 avatar, and comparison with current access to educational material. Users
258 were also asked to identify any barriers or concerns about the use of this
259 technology.
260
261 Data collection was similar to Phase One, with the additional option of
262 supplementing with photos and sketches. Notes and transcripts from both the
263 user studies were translated, and analysed thematically[18].
264
265

Results

Discover

1. Desk Research

The HUSI clinicians noted that patients often have health literacy and knowledge limitations, and that 10- or 20-minute consultations (primary and secondary care, respectively) do not provide sufficient time to communicate critical information. They unanimously agreed, together with the advisory board, that hypoglycemia was a key subject area to focus on. Key learning needs were derived from the clinicians' observations and assumptions (see extract in Table 1).

People in Colombia receive information via a variety of sources, including face-to-face education, printed leaflets provided by their local hospital, online content, communities, and personalized training, and this continues throughout their journey – from diagnosis through to continued care (as summarized in Fig. 3).

2. Phase One User Study

36 participants responded to the web survey, with a mean age of 54 (19-82). Most people rated their health literacy as high: average understanding was 4.5

(out of 5), regarding both their condition and medication (though the range was 2-5). 86% of the cohort had a time since diagnosis of >5 years (see Table 2).

The majority were well-educated (78% higher education), and 33 of 36 (91%) were receptive to the prospect of educational interventions to help them self-manage (with 58% responding "yes" and 33% "maybe") when asked *"Do you think you need more information in order to control your condition better?"*). Respondents were allowed to select multiple options when asked how they prefer to access health information. 26 participants (72%) selected "Speaking directly with your doctor or nurse", with 18 (50%) citing "videos, TV shows or computer animations". When asked about health information sources *other* than doctors, 64% relied on family alone, with a few also citing friends. 8 of 36 (22%) listed support groups, such as social media, and 28% did not rely on anyone apart from themselves. All respondents felt that lifestyle changes can have a positive impact on health, meaning that participant 'buy-in' was not necessarily an obstacle for this study to overcome.

Respondents were asked to rank topics of interest from a pre-set list. Results are shown in Table 3. Hypoglycemia ranked highly, and additional suggestions included nutrition and alcohol consumption. The responses, ranging from "Very useful" to "Not very useful" are grouped by participant characteristic in Table 4. The two respondents who answered "Not very useful", were not insulin-dependent.

In telephone interviews (n=5), participants reported that they were unaware of some problems related to inadequate glucose control, they had encountered issues in their professional and social lives, and were frequently supported by family. The interviews also uncovered unexpected aspects, such as the potential impact of personal time limitations on self-management. Almost all people interviewed thought that a programme on hypoglycemia would be very useful, particularly how to manage severe episodes.

Define

The pilot topic was defined to be hypoglycemia. The target audience was characterized using personas, to capture individual demographics, journeys and health education needs, together with fears and frustrations. An example is show in Fig. 4.

The final output of Phase One was the definition of the curriculum for the pilot module. The learning objectives, and contextual information are shown in Table 5.

334 *Develop*

335

336 The approved curriculum was converted into a story flow to guide the viewer
337 through the content (see Fig. 5). A site map was also created, to allow viewers
338 to skip or navigate to different scenes at any point during the programme. The
339 immersive content was then produced, together with a Spanish script,
340 narrated by a native Colombian speaker, to aid familiarity.

341

342 In response to results obtained from earlier phases, three pilot programmes
343 were developed. Each prototype comprised a three-minute excerpt of a full
344 hypoglycemia programme, focusing on causes and symptoms, in order to
345 rapidly identify a mild-moderate event. Prototypes included exactly the same
346 narration and content, but visual approaches were very different (see Fig. 6).

347

348 *Deliver*

349

350 The three prototypes were tested by 17 participants (see Table 2), who gave
351 feedback via the web survey. All respondents were insulin-dependent, and
352 88% had T1D. Ten participants also attended one of two online focus groups,
353 each for five people. The data were transcribed and translated into English for
354 analysis.

355

356 16 of 17 (94%) responded “yes” and 1 (6%) “not sure” when asked “Would you
357 use a program like this again to learn more about your health?”. In response

to the question “Did you like the program?” 15 of 17 (88%) said “Yes” and 2 said “OK”. There was a marked improvement in self-reported knowledge (see Fig. 7), and qualitative analysis of comments also revealed a clear pattern of positivity for all three prototypes (see Table 6). All three prototypes were considered to be very interesting, relevant, novel, and comprehensive educational tools. Notably, one person had never been informed as to what hypoglycemia was, and had actually been experiencing events and mistaking them for perimenopausal symptoms.

Participants provided positive feedback on the vocabulary, visuals, sound, content and topic of choice. They also reacted favourably towards this mode of delivery, and believed that VR holds value as an effective and appealing medium. There were very few technical issues, and participants suggested technical enhancements, such as adding augmented reality, or animating the avatar to describe symptoms.

The 3D video with a realistic avatar (Prototype 1) generated the most positive response in the qualitative data analysis (see Table 7). Participants cited the familiarity of the home environment and the immersive VR element, for example. They were less keen on the robot (Prototype 2), commenting that it was “impersonal”. Responses were mixed however, and participants liked all options, with some describing Prototype 3 as “easier to understand”. Additional topics were also proposed, including diabetes in general, symptoms of hypoglycemia versus epilepsy, and hyperglycemia.

Discussion

The main goal of this QI study was to evaluate the potential of an avatar-based programme to educate PWD in Colombia. Hypoglycemia reduces health-related quality of life[26,27], and 25% of PWD struggle with hypo-anxiety[21]. Importantly, many hypoglycemic events are avoidable, so an educational intervention could be highly effective. The methodology relied on collaborative working with Colombian clinicians and PWD, and the use of a structured method, all of which are essential components for effective QI[28]. The results suggest that, overall, immersive video technology has a high level of acceptability as an educational intervention, both by PWD and expert clinicians.

The feedback on all three prototypes was enormously positive. Survey data supported our hypothesis that immersive video technology could be an appealing format, and that participant 'buy-in' was not necessarily an obstacle for this pilot to overcome. All versions were considered to be very effective educational tools, with potential to educate even beyond the clinical setting. The 3D video with a realistic avatar was the most highly rated, and the need for such engaging, remote education was reinforced by the pandemic.

People were responsive to the prospect of educational intervention and believed that positive lifestyle changes can have a beneficial impact on

406 outcomes. The curriculum topics were useful, but future work should consider
407 covering vision, self-care, and emotional support. Some additional issues
408 emerged, such as time limitations of PWD. The technical delivery went very
409 smoothly: most people could access the content easily on their phones. The
410 results indicate that even these short 3-minute prototypes may have positive
411 influence on quality of life, and confirm the need to empower PWD through
412 knowledge, perhaps as a priority for type 2 diabetes, where care may be more
413 oriented towards reducing hyperglycemia[29].
414
415 The study was not without its challenges. The Covid-19 pandemic meant that
416 all activities had to be moved online, incurring a delay in the approval of the
417 amended ethics submission. The pandemic also intensified the HUSI clinicians'
418 workload. The online execution did have the advantage that Spanish-speaking
419 investigators based in the UK could participate however. There were also
420 logistical challenges: Covid-19 disrupted the Colombian postal services, leading
421 to delays in delivery of the Google Cardboard headsets. Language introduced
422 another obstacle, since all research materials needed to be translated to
423 Spanish and vice versa for the data analysis. Fortunately, the multidisciplinary
424 nature of the team made it highly adaptable to overcoming such development
425 challenges.
426
427 This research does have limitations, since it is based on feedback from one
428 hospital (HUSI) in one region of Colombia (Bogotá). Results were self-reported,
429 study size was small, and the cohort included many people with a high level of

education and long diabetes duration. Nevertheless, this QI study demonstrates how immersive technology has potential for use either in clinical settings or diabetes education centres as an adjunct to current educational practices. The educational prescription model in Fig. 2 outlines the simple, practical approach that could be used, for example, to provide basic information, thereby alleviating healthcare practitioners to focus on different content.

Conclusions

The results of this work show that it is possible to conclude that immersive video technology has the potential to deliver patient education in Colombia, via smartphone. The human-centred design methodology proved vital in understanding the target audience and their perceived needs. The work also highlighted the importance of involving experienced diabetes-specialist clinicians in the content development process, to ascertain their expert perspective of individual health education needs.

Although existing research has demonstrated the benefits of using VR to educate clinical practitioners[15,30], this is the first report of a 3D avatar-based diabetes education programme for patients in Colombia. One reason for this could be the prohibitive cost of deploying such an intervention at scale, or unfamiliarity with the appropriate equipment. These barriers have been

454 removed by delivering the programme via smartphone, together with an
455 affordable headset. The results are timely, since the pandemic has
456 exacerbated the need for such digital, remote, instructive technology. Future
457 work includes development of additional content, evaluation with a larger
458 group using validated tools, and exploration of the role of artificial intelligence
459 in personalising this form of education.
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Tables

Observation	Assumption	Action
Pilot topic of choice: Hypoglycaemia		
● People receiving insulin or certain oral medications often report that they struggle with hypoglycaemia (impacting quality of life and HCP time/costs) ● Hypo anxiety and weight gain in people receiving such agents ● Lack of knowledge and clear need for further support	● People do not always fully understand their condition or medication ● People would benefit from an effective educational intervention ● Unmet learning needs are: preventing hypos, detecting hypos, treating hypos, dosing, self-care, sick-day rules, impact on driving ● People experience hypoglycaemia differently, which could make detection more difficult ● Educational needs may be different, for example newly diagnosed vs longer term diagnosis ● Hypo anxiety is a significant issue and could be addressed by improving knowledge of their condition and medication	● Pilot module content, language and flow has been shaped around these challenges ● Decided approach/language needs to be calming, hopeful, optimistic, informative ● Module to allow for user-led navigation so that people can access information most relevant to them

Table 1. Extract from clinicians' observations in routine practice in Colombia

	Phase 1		Phase 2	
Demographic	**n**	**%**	**n**	**%**
Time since diagnosis				
>5 years	31	86	15	94
2-5 years	2	6	1	6
<2 years	3	8	0	0
Gender				
Male	16	44	5	31
Female	20	56	11	69
Diabetes type				
Type 1	22	61	14	88
Type 2	14	39	2	12
Smoking status				
Occasional smoker	4	11	0	0
Non-smoker	31	86	16	100
No response	1	3	0	0
Treatment				
Insulin only	25	69	14	88
Insulin and tablets	8	22	2	12
Tablets only	3	8	0	0

Table 2. Participant demographics. Diabetes duration, gender, type, smoker, treatment. Note that percentages are rounded to integers, and one Phase 2 respondent declined to provide demographic information.

	Topic	Score*
Most useful	How diabetes can affect vision	111
	Self-care (e.g. diet, exercise)	111
	Emotional support (e.g. depression, anxiety)	110
	Hypoglycaemia	109
	How to use medicines	109
	Heart and kidney issues associated with diabetes	107
	Foot and nervous system issues associated with diabetes	107
	Diabetes and infections	107
	Technology	106
	Diabetes and covid-19	106
	What is diabetes?	104
	Check-ups required if you have diabetes	102
Least useful	How diabetes may affect driving	92

Table 3. Usefulness of topics as graded by web survey respondents.
*Based on scores: not useful (0), not very useful (1), OK (2), useful (3), very useful (4) assigned per respondent; therefore lowest score possible = 0, highest score possible = 144.

	Very useful		Useful		OK		Not very useful	
Demographic	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Gender								
Male	3	25	10	67	3	43	0	0
Female	9	75	5	33	4	57	2	100
Diabetes type								
Type 1	12	100	7	47	3	43	0	0
Type 2	0	0	8	53	4	57	2	100
Treatment								
Insulin	12	100	9	60	4	57	0	0
Insulin & Tablets	0	0	6	40	2	29	0	0
Tablets only	0	0	0	0	1	14	2	100
Time since diagnosis								
> 5 years	12	100	14	93	4	57	1	50
2 - 5 years	0	0	1	7	1	14	0	0
< 2 years	0	0		0	2	29	1	50
Educational level								
Higher Education	11	92	12	80	5	71	0	0
High School Diploma	1	8	1	7	1	14	1	50
Primary Education	0	0	2	13	0	0	1	50
No education	0	0	0	0	1	14	0	0

Table 4. Response, by characteristic), to the question “How useful do you consider the following topic: How to treat and avoid hypoglycemia?” (n=36)

LEARNING OBJECTIVES:	
● Improved ability to recognize hypoglycaemia ● Understanding of how to treat mild-to-moderate hypoglycaemia, what to do in severe cases, and how to be prepared for an event ● Increased awareness of factors/situations that increase the risk of hypoglycaemia, and how to avoid these	
Audience	
Age	Adults
Literacy level	Accommodate for low literacy levels by using visual and aural aids, without alienating/patronizing those with higher literacy skills
Issues	● On average, people with type 1 diabetes (T1D) experience up to two episodes of mild hypoglycaemia a week, and up to two serious events per year[19] ● Severe hypoglycaemia is associated with an increased risk of mortality[20], and associated anxiety may have a significant impact on quality of life[21] ● People may not be aware of what hypoglycaemia is, how to recognize symptoms and/or how to treat an event ● At-risk and anxious people may overeat to raise their blood sugar levels, causing weight gain, and they may become reluctant to take their medication as prescribed[22]; both factors increase their risk of diabetes-related complications ● Increasing awareness and ability to self-manage may reduce incidence of events and relieve anxiety
Context	People with existing or recently diagnosed T1D or type 2 diabetes (T2D) at risk of/struggling with hypoglycaemia, receiving such agents as prandial glucose regulators, insulin and/or sulfonylureas
Approach	
Language	Non-technical yet not patronizing.
Voice	● Reassuring and positive; 25% of people with diabetes suffer 'hypo anxiety'[21] ● Realistic and supportive
Visuals	Educational, interactive, engaging
VR presence	Calming, welcoming, interesting Stylised as opposed to graphic, realistic, or clinical
Music	Calming, clinical/slightly abstract, familiar

Table 5. Pilot module curriculum

Topic	**Comment**
Ease of use	"I have 44 years of being diabetic and I have used a lot of literature. As a child I did not understand and I was bored but now with this technology a child can learn. The videos are very compact and easy to understand, they teach you clearly. Videos like these can be used to educate everyone."
Visual presentation	"I have had diabetes since I was 5 years old and I have seen everything from books, guides, brochures, group workshops, medical visits. All that is boring and you don't pay attention, the videos are very friendly and help to gain interest, they involve you with your sight and hearing and educate you better."

Unmet needs	"I am type 2 diabetic. I found the video excellent and I have learned a lot, I did not know that hypos existed. No one had told me anything. I had all the symptoms described in the video but I did not know what it was and my family told me it was pre-menopause…I think it's great to have a video that can be seen at any time because I don't have time to read brochures and books."

591 Table 6. Indicative comments from two 3-hour focus groups, with regard to the
592 overall experience of the pilot study.
593
594
595

Likes/dislikes	Example Feedback
Prototype 1	
● **Most preferred** prototype: favourite avatar, favourite environment, explains the concept best ● Enjoyed the 3D immersive VR element ● Visuals were relatable and familiar ● Inside the bloodstream is incredibly visual, engaging, and aids understanding - The content looks too distant - Some participants had issues viewing this content	● "The guided tour of the bloodstream in 3D is what I liked the most, super interesting. I did not imagine it this way" ● "The 3D prototype is more immersive, you see the red blood cells, the adverse effects, the explanation, the scale is very explanatory" ● "The use of virtual reality making the experience more immersive" ● "Because it is three-dimensional, very striking, which makes it focus on the information, and not be monotonous" ● "I like that environment because it seemed more pleasant, familiar." ● "Prototype 1 is the most complete, you stay immersed and it makes you concentrate" ● "The headset is important for concentration. The novelty of getting into the bloodstream and seeing the red blood cells, it's compact and well done" ● "It looks real, like a human being, like you or me"; "More android"
Prototype 2	
● **Second preference**, tying with prototype 3 ● Respondents enjoyed the animation, and thought that the video was eye-catching ● The void space is less distracting, drawing more attention to the visuals - The robot is very impersonal	● "More eye-catching for a 3d video" ● "I liked the robot as it enters to see the red blood cells, it is very striking" ● "I don't want to think that I'm a robot" ● "Very impersonal. Far from your reality" ● "He did not identify me with that character" ● "Prototype 2 is best when you don't have the Google Cardboard headset"
Prototype 3	
● **Second preference**, tying with prototype 2 ● People identified with the characters and found the content easy to understand - The content format is less original	● "I identified more with this option" ● "It is easier to understand" ● "It is something very common" ● "Prototype 3 is more educational with a very striking background"

Table 7. Example comments from two 3-hour focus group sessions and a web survey, indicating preferences regarding the different presentation modes of the three prototypes.

Figures

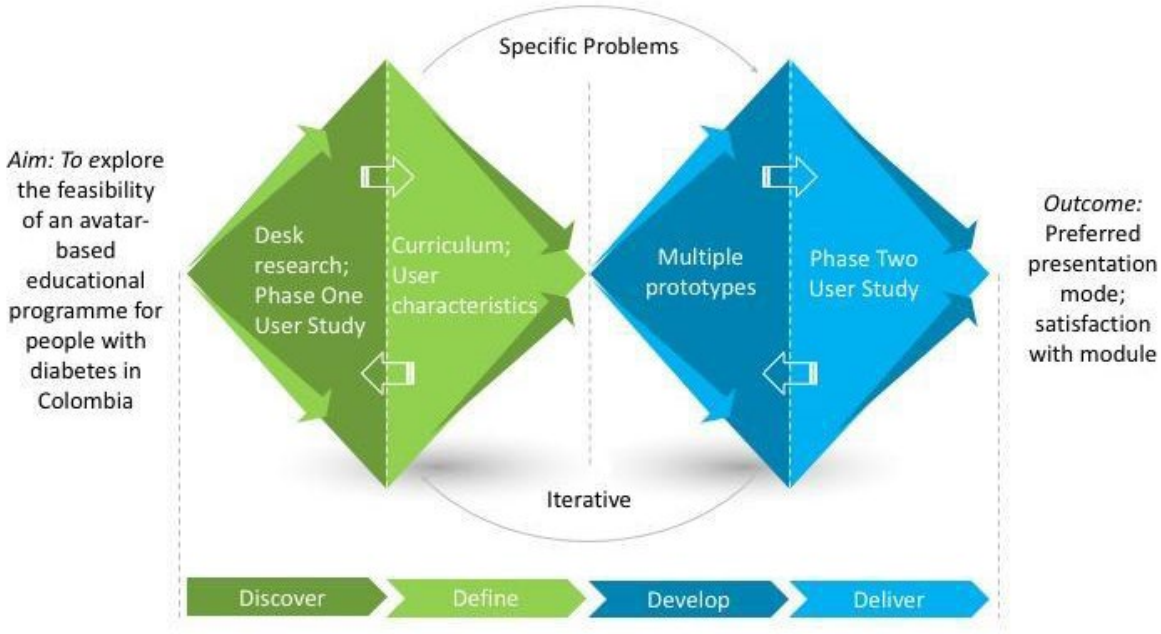


Fig. 1. ABLEDOC Double Diamond Design Process[1]

[1]This figure was designed using a template from PoweredTemplate.com

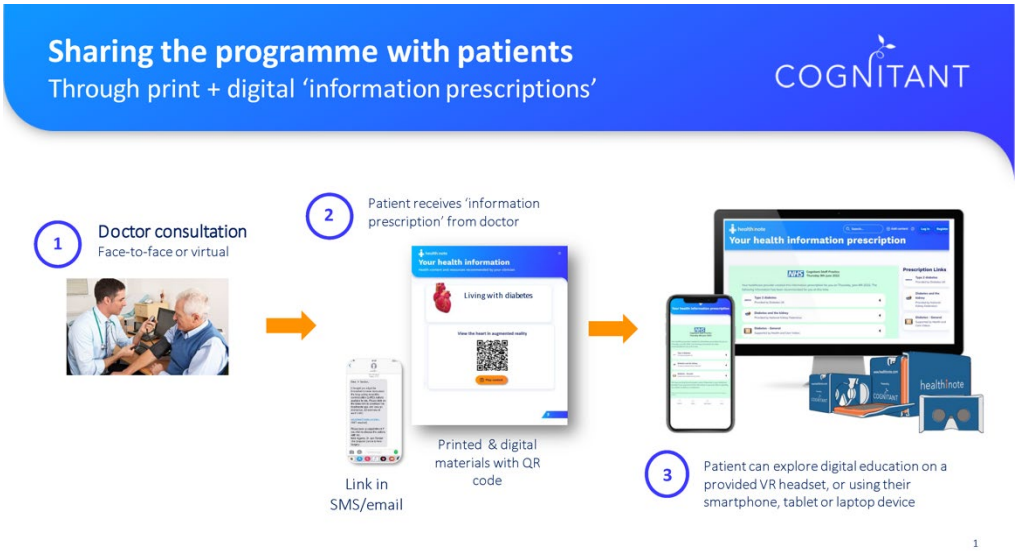


Fig. 2. Cognitant's educational prescription model, via Healthinote

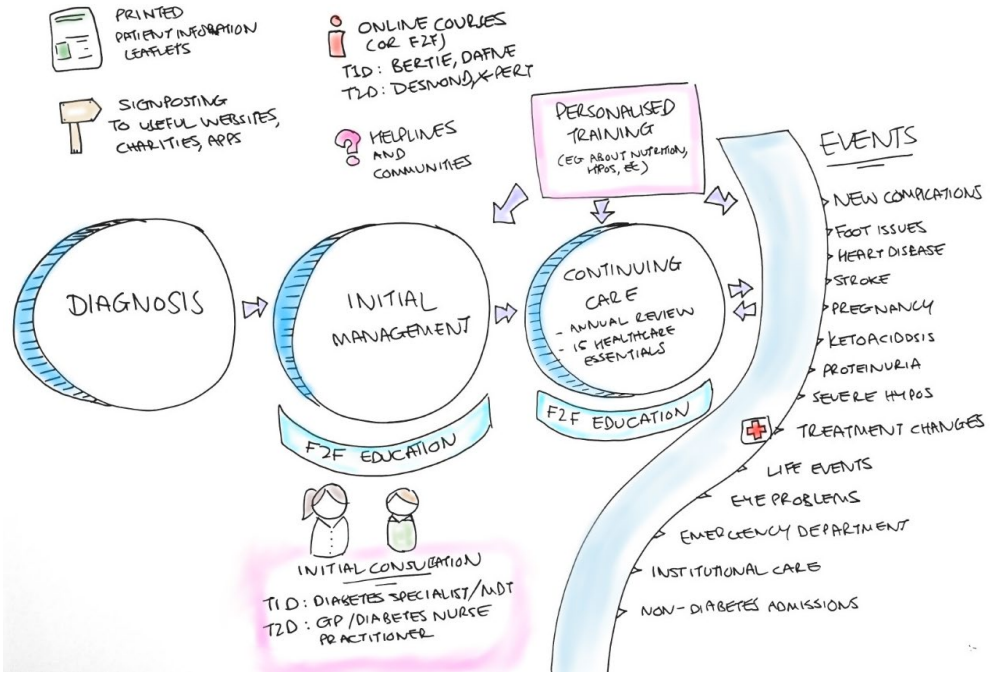


Fig. 3. Desk research into health information access in Colombia. F2F: Face to face; T1D: Type 1 diabetes; T2D: Type 2 diabetes.

Demographic Profile of "Isabel"

- Single mother of two
- Domestic worker
- Type 2 diabetes
- Diabetes duration 10 years

"Well, a normal day, as I'm so medicated, with so much insulin, it's super-complicated."

"That was what motivated me, because I do not want to get sick again in the short term as those affected most are my children."

Health education needs

- Learn more about treatment options, adjustments and technology
- Emotional aspects "every day I find myself anxious, concerned, anguished"
- Hyperglycaemia an issue

Worries, fears and obstacles

- Juggling work, looking after children, household chores, little time to think about medication "My children depend 100% on me"
- Trying to obtain permission for medical appointments from work
- Finding time to exercise

Isabel's journey

- "At the beginning, when I was very unwell, it had me super-worried and forced me to go to the doctor so that they would realise how out of control I was due to diabetes"
- Issues with sleep and exercise, which have improved with time

Family support

Isabel relies heavily on her mother, who helps her look after

• Side-effects of medication (semaglutide) • Motivation to improve her health was driven largely by caring responsibilities • Currently more stable, but still eager to learn more about her condition and treatment options.	her condition and regularly provides support and advice

Fig. 4. Participant persona, as noted from 1:1 conversations with real-life people with diabetes in Colombia. The name is fictional, but details are based on a real person's details and quotes (translated from Spanish).

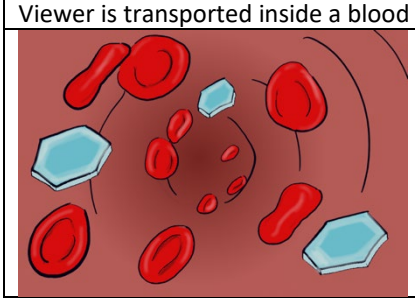
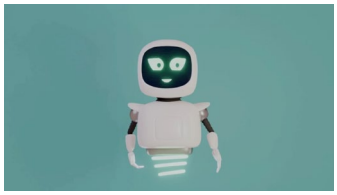
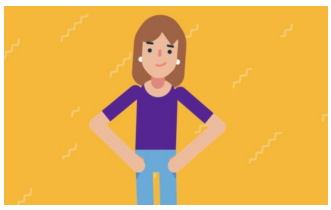
OPENING SCENE: MODULE INTRODUCTION	
Patient is welcomed to the module by a physician avatar. Surroundings are familiar, relaxing and non-clinical.	
	Module introduction: • Outline programme contents and purpose • Provide viewers with the option to self-navigate or watch whole module On-screen options: 1. About hypoglycaemia 2. Treatment 3. Avoiding hypoglycaemia
SCENE 1: ABOUT HYPOGLYCEMIA	
Viewer is transported inside a blood vessel, where red blood cells and stylized glucose molecules are flowing.	
	Here, the avatar explains: • what the viewers can see • topline basics of glucose homeostasis • what hypoglycaemia (and hyperglycaemia) is Viewers will be able to interact with their environment, for example: HbA1c could be manually adjustable, glucose molecules could be movable, etc.

Fig. 5. Extract from pilot module story flow

Prototype 1:
Interactive 3D module with realistic human avatar and environment. Can be viewed in virtual reality (VR) using a Google Cardboard headset.
View on YouTube[23]



Prototype 2:
High-quality 2D video with 3D models, stylised robot avatar and void environment. Cannot be viewed in VR.
View on YouTube[24]



Prototype 3:
2D stylised explainer video. Cannot be viewed in VR.
View on YouTube[25]

Fig. 6. Pilot module prototypes

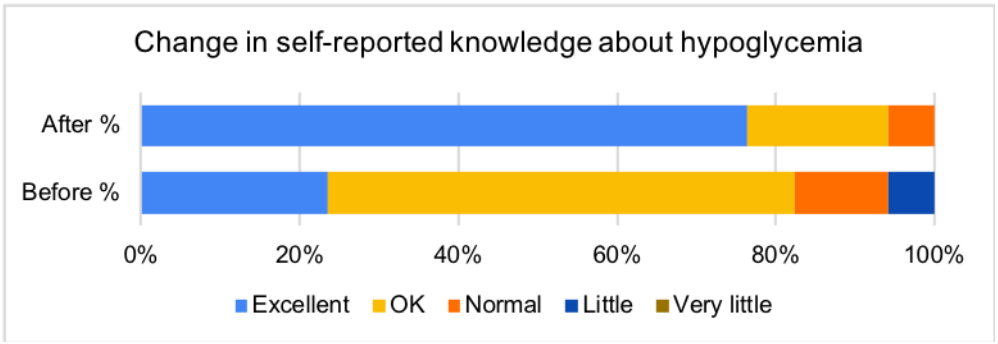


Fig. 7. Response to the question: "How would you rate your knowledge about hypoglycemia and how to handle it?" before and after the intervention (n=17)