

Chapter 5

Experimental validation

The educational value of the Edutool must be determined to validate the development of this simulation model. The evaluation will be questionnaire-based. Two different age groups of non-diabetic people will complete the questionnaires and the results will be statistically analysed. In this chapter the development of the questionnaires, its validation and the protocol for the trials will be discussed.

5.1 Introduction

In the last two decades a wide variety of diabetes simulation models and educational tools have been developed, the most salient of which are:

- AIDA (Blanchard *et al.*, 1998)
- MINMOD (Pacini and Bergman, 1986)
- KADIS[®] (Rutscher *et al.*, 1994)
- DiasNet (Plougmann *et al.*, 2001)
- DIABLOG (Biermann and Mehnert, 1990)

Even though these models have intuitively been accepted as beneficial and necessary, it is still required to assess these models to determine their value (Tatti and Lehmann, 2001).

Experimental validation of educational tools for people with diabetes is limited (Hk, 2008). The empirical assessment of these tools ensures a higher quality of care for diabetics by improving the educational value of the tools (Bohensky *et al.*, 2011). Diabetics require long-term management and guidance to improve their self-management. Educational programs, as well as educational software, are developed for this reason.

Thus, the evaluation of the *EduTool* diabetes simulator is necessary to determine the success of the educational software by allowing unbiased users to assess it. The evaluation was questionnaire-based and the results were statistically analysed. Three questionnaires were developed, namely a pre-trial questionnaire (Diabetes *EduTool* Questionnaire 1), a post-trial questionnaire (Diabetes *EduTool* Questionnaire 2), and a preference questionnaire (Diabetes Questionnaire 3).

Although the software was developed to simulate a person with type 1 diabetes, it can also be used to educate non-diabetic people on the subject of diabetes and BG. The evaluation of the *EduTool* must therefore be completed by non-diabetic people as well as people with diabetes. If the *EduTool* and questionnaires can be understood and the trials successfully completed by people that have little or none pre-knowledge on the subject, then it will definitely be understood by adults and diabetics.

For the purpose of this study, only non-diabetic people will assess the software. This is due to the time consuming process of establishing contact with people with diabetes through their

doctors. It is necessary to establish contact in this formal manner to ensure a professional relationship to make sure an unbiased evaluation is accomplished.

Two different age groups (approximately 13 years old and 17 years old) of non-diabetic people assessed the software based on the questionnaires developed specifically for this trial. The participants first completed a theory-based questionnaire to determine their knowledge regarding BG and diabetes. Secondly, they watched a quick-start guide presentation that described basic BG and diabetes concepts; and contained an explanation of how the *Edutool* works.

Afterwards they were asked to answer an analytical, specific insulin-related question in order to test if they could use the *Edutool*. The participants were requested to complete a theory-based questionnaire again. The group was then asked to work on the AIDA simulator after which a similar insulin-related question was asked. Finally, the participants completed a short questionnaire that tested the model's ease-of-use and asked the participants which educational model they would prefer.

5.2 Development of the quick-start guide presentation

To elucidate the basic features and mechanisms of the *Edutool* diabetes simulator, a quick-start guide presentation was developed. This presentation introduces basic BG and diabetes concepts and explains these concepts in a manner that children would understand. This presentation gives *Edutool* users the basic knowledge to operate the program without them having to figure it out for themselves. This saves the users time and effort and increases the educational value of the simulation model.

The presentation starts off by explaining what BG is and why a person requires enough BG in their blood to sustain life. Next, it is explained what insulin is and how the hormone works to reduce the BGL, followed by the effect of exercise and stress on the BGL. Lastly, type 1 diabetes is also explained.

After the introduction to these basic concepts, the features, and how the *Edutool* diabetes simulator works, are described. At the end of this description a quick example is shown of how, using the *Edutool*, the insulin dosage after a meal for a type 1 diabetic can be determined. This example is similar to an insulin question found in the questionnaire that the

participants would have to complete after watching the presentation. The presentation can be seen in Appendix B.

Several videos depicting how the *EduTool* works were embedded within the presentation. The entire presentation was also voice-recorded to make the quick-start guide easier to use. These features are intended to enable the user to watch the quick-start guide presentation and absorb the knowledge it presents without difficulty. In the near future the entire quick-start guide will be available from the *EduTool* website (www.diabetic-EduTool.com). The quick-start guide will be included in the electronic Appendix, D, along with the *EduTool*.

5.3 Questionnaire development and validation

The questionnaires were developed through the selective perusal of several questionnaires previously developed for evaluating diabetes educational simulation models (Boisen, 2006; Lehmann *et al.*, 2006; Garcia, 2001; Paddock *et al.*, 2000). By selecting a relevant question pool, as well as adding questions specific to the *EduTool*, the current questionnaires were developed. Different experts were asked to evaluate the questionnaires to validate the questions based on relevance, difficulty, and diabetes knowledge.

Development

The first step in the development of the *EduTool* evaluation questionnaire was to establish the objectives of the study. The questions were chosen accordingly. The primary objective was to assess the educational value of the model, but secondary objectives also existed. The simplicity and user-friendliness were also very important to ensure the success of the software. These objectives were integrated with the different sections of the developed questionnaires.

Firstly, pilot questionnaires were developed to be assessed and evaluated by three experts in the field of diabetes and endocrinology. After several of the recommendations and comments were implemented, the questionnaires were piloted in a non-expert group. This group included a nine year old girl and several colleagues, which then had to further assess the questionnaires. Following this process, the final questionnaires were developed.

Three questionnaires were developed, namely, pre-trial, post-trial, and preference questionnaire. To test the baseline knowledge of the user, several sections in the pre-trial questionnaire were devoted to assess the user's basic and BG knowledge, as well as computer literacy skills. This baseline data was used to assess the improvement in the user's knowledge after completion of the presentation (and the insulin-related question presented after the presentation). Thus, indicating the educational value of the software.

After the presentation and question, the participants would complete the same theory-based questionnaire combined with a few questions regarding the user-friendliness of the program. These questions, would in turn, be compared to similar questions answered regarding the AIDA simulator.

It must be noted, as explained further in the trial protocol, that the AIDA diabetes simulation model was also evaluated. The group of participants evaluated this model after completion of the *Edutool* evaluation. The questionnaires used in these groups were similar to the *Edutool* group's questionnaires. This serves as a baseline model to which the *Edutool* could be compared.

Non-diabetic people from two different age groups were chosen to assess *Edutool*. This was done to establish the level of knowledge at different time periods in a person's development. Each age group (i.e. the grade 7 students and grade 11 students) had a questionnaire that was appropriate for their level of understanding and knowledge. The questionnaires were validated by professionals in the field of diabetes and endocrinology.

Validation

The validation of the questionnaires was necessary to ensure that the relevance and difficulty of the questions were within an acceptable range. Therefore, three experts in the field of diabetes and endocrinology were asked to assess the questionnaires based on these criteria. The revised questionnaires were then further assessed by a non-expert group. After completion of this process, the questionnaires were finalised.

The first expert was Prof. Jim Mann. He has been professor in human nutrition and medicine at the University of Otago and consultant physician (endocrinology) at Dunedin Hospital for 22 years. In the preceding years he lectured at the University of Oxford and worked as a

consultant physician at the Radcliffe Infirmary. He is also the director of the Edgar National Centre for Diabetes and Obesity Research (ENCDOR) and the WHO Collaborating Centre for Human Nutrition (Otago University, 2011).

The other expert is Mr Michael Brown from the Centre for Diabetes and Endocrinology (CDE) in Johannesburg. He is head of the educational department. Dr Larry Distiller, head and founder of the CDE, recommended Mr Brown. Mr Brown is the editor of a journal published quarterly by the CDE, i.e. Diabetes Lifestyle. This journal uses case studies to convey important lifestyle and BG control information to the CDE diabetes community. The CDE currently has 18 000 members throughout South Africa.

Dr Jacomien de Villiers, an internist and endocrinologist has a private practice for people with diabetes or metabolic syndrome. She consults only part-time, since she also works at the Steve Biko Academic Hospital in Pretoria. Her associate Dr Tanja Kemp, who also works at the hospital, has allowed access to several of the patients at the diabetes clinic on which the model can be tested. Dr de Villiers is the third expert to validate the questionnaires.

The recommendations and comments from these experts are listed below:

1. The language used in the questions should be simplified to the level where a child would understand. (This was done in all questionnaires and the presentation).
2. Diabetes is a condition and not a disease. (This was implemented in all questionnaires).
3. Rather use blood sugar, than blood glucose. (This was implemented where possible).
4. Try to minimise the use of the term diabetic, rather say a person with diabetes. (This was also implemented where possible).
5. Do not refer to signs of diabetes, rather refer to symptoms. (These questions were removed from the questionnaires due to the level of difficulty).
6. Do not ask questions with multiple answers. (The questions were changed accordingly).
7. The questions should be very direct and clear.
8. Make sure the questions do not implicate diabetes in a negative way.
9. The *Edutool* is designed for literate people that can use and have access to a computer and is therefore only for a specific group of people.
10. If a person with diabetes would use this program, that person should be highly motivated to control his or her BG.

These recommendations were implemented where possible and all comments were taken into consideration in the design of the final questionnaires. The three questionnaires are included in Appendix A. The protocol developed for the trials will be discussed in the next section.

5.4 Protocol for questionnaire-based evaluation of *Edutool* diabetes simulator

A scientific method, based on the method developed by Tatti and Lehmann (2001) for the randomised-controlled clinical trial of the AIDA simulator, was developed for the questionnaire-based evaluation of the *Edutool*. A protocol for the trial then had to be developed to define the procedure of how the evaluation should take place. This protocol is presented in the next section. The main goal of the protocol was to explain what would happen prior to the trial, on the day of the trial, as well as after the trial.

Protocol for the experimental trials

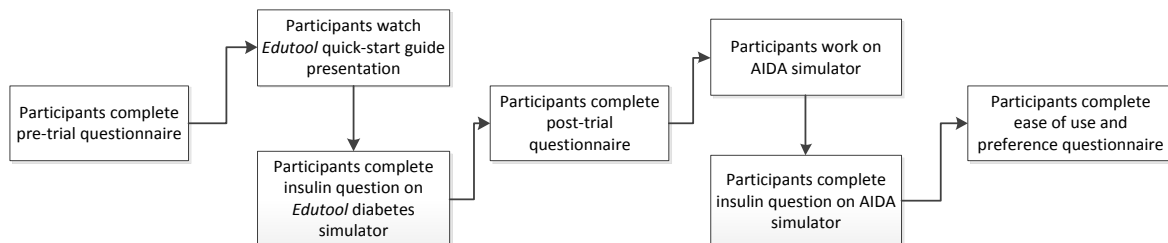


Figure 39: Trial protocol (adapted from Tatti and Lehmann, 2001).

Step 1: Questionnaire development

The development of the questionnaires started with the selection of the main goals for the experimental validation. The main goals were to evaluate the educational value, user-friendliness and the user's understanding of the simulation. The *Edutool* was developed to educate type 1 diabetes patients, non-diabetic people, care givers and medical professionals on the integrated effects of external and internal influences on their BG and what effect this may have on their BGL and glycaemic control.

Pre- and post-trial questionnaires (Diabetes *Edu*tool Questionnaire 1 and 2) were developed to assess the *Edu*tool. A third questionnaire (Diabetes Questionnaire 3) was also developed to compare the *Edu*tool to the AIDA simulator. An insulin-related question was also included in both the post-trial questionnaire and the third questionnaire.

Several categories were chosen to compartmentalise the questions, though the categories were not explicitly indicated. These categories comprised personal information, basic knowledge, BG knowledge, and computer literacy.

Step 2: Questionnaire validation

The validation of the questionnaires by medical or diabetes professionals were essential to ensure the questions were clear, concise and relevant to this specific field of study. Professionals in this field might have questions to add that would benefit the study and improve the outcome of the results.

Step 3: Subjects

The age groups chosen to evaluate this model included primary school learners (approximately 13 years old) and secondary school learners (approximately 17 years old). The different groups would reveal the participants' level of knowledge on this subject at that particular age and therefore give insight into at which age an educational tool might be needed. All participants had to sign an information release form. The minors participating in the study had to have a minor information form signed by their parents or guardian before they could participate.

Step 4: Protocol followed on the day of the trial

1. It was ensured that all participating subjects returned their signed information release forms.
2. A brief presentation on the proceedings of the trial was given.
3. All participants were allowed to sit at any computer, thus ensuring a random distribution of participants. The participants were not allowed to write their names, or any personal details, on any questionnaire. The questionnaires would also not be numbered.

4. The group completed the pre-trial questionnaire (Diabetes *Edutool* Questionnaire 1) before starting to work on the *Edutool* simulation model. They had approximately 10 minutes to complete the questionnaire.
5. The group then started the quick-start presentation, followed by the completion of an insulin question that required the use of the *Edutool*.
6. The post-trial questionnaire (Diabetes *Edutool* Questionnaire 2) could then be completed. The participants were allowed approximately 20 minutes to watch the presentation, complete the analytical insulin-related question and answer the questionnaire.
7. Next, the participants had approximately 10 minutes to work on the AIDA simulator and complete a similar insulin question.
8. An ease-of-use and preference questionnaire was then completed (Diabetes Questionnaire 3).
9. The groups were thanked for their time in a brief concluding presentation and each participant received a small gift.

Step 5: Processing the results

During this phase the results from each age group were processed and statistically analysed.

Step 6: Writing up

This phase comprised the results from the experimental trials to be written up in a formal study report.

Step 7: Feedback

Feedback was provided to each of the trial participants. Minors and school learners were provided with a letter of thanks for their participation. A brief summary of the results and conclusions were given.

5.5 Trial

The trial can be divided into two main categories, namely the primary school trial and the secondary school trial. Both the trials took place at the Curro schools in Hazeldean, Pretoria. The protocol for each of the trials was the same as the protocol presented above.

Preparation for the trials

The first step in the preparation for the trial was to establish contact with a primary- and secondary school that would be willing to participate in this diabetes awareness trial. Several schools were contacted, but declined to participate. Curro Hazeldean Primary School and Curro College Hazeldean, both in Pretoria were willing to participate in the trials.

Mr Roux Viljoen, the departmental head of the grade 4 to 7 learners, facilitated the trial at the primary school. The headmaster of the school approved of the trial protocol, questionnaires and software to be used. Mr Viljoen made sure all learners received and returned the information release forms.

Mrs Louise Werner, the head of marketing for Curro College Hazeldean, in conjunction with the headmaster of the school, approved the necessary documentation and software for the trial. Mr Wayne van Zyl, the Life Orientation teacher for the senior learners, facilitated the trial by making sure the information release forms were returned by all participants and the classroom where the trial would take place was booked for the trial.

During the trial, each participant required a computer to ensure individual software evaluation. Loading the software onto the Curro schools' computers was a time-consuming process due to protocol set out by the management of the schools. Therefore, laptops were required for each participant taking part in the trial.

At the start of the trial 18 laptops were available for use. The *Edutool* and AIDA software, as well as the quick-start presentation, had to be loaded onto each laptop. Also, all the laptops had to be fully charged in case of a power failure. This was all done in the days prior to the first trial.

The questionnaires were printed and gift bags were made up with North-West University bags, pamphlets, pens and rulers. Also included in the bag were a Jungle Energy Bar and a Fizz Pop lollipop.

Primary school trial

In the class of 20 learners, 18 returned their signed information release forms and one learner was absent on the day of the trial. This left 17 grade 7 learners that could participate in the trial. The participants were not numbered, and therefore the trial was completely randomised.

Secondary school trial

In the class of 18 learners, all 18 returned their signed information release forms. On the day of the trial, two learners were absent from this class and therefore only 16 learners participated in the trial. The same randomisation techniques were applied to the secondary school participants as was discussed in the summary of the primary school trial above.

The secondary school trial at Curro College Hazeldean is shown in Figure 40.

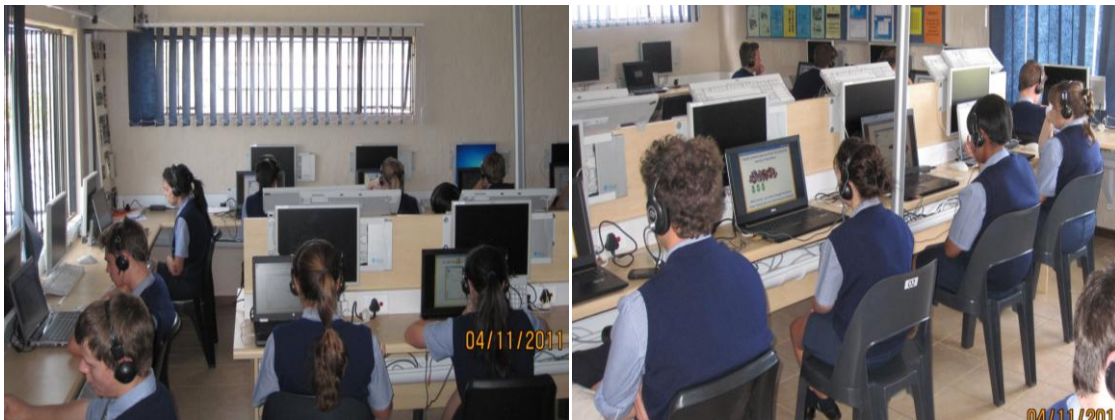


Figure 40: Secondary school trial at Curro College Hazeldean.

Conclusion

On the day of the trials, there were 17 primary school learners and 16 secondary school learners that participated. Laptops with the necessary software were set up for each participant. All three questionnaires were printed and handed to all participants during the trial.

5.6 Results and discussion

The results will be presented in the order of the completed questionnaires, with the graphs and analysis of the data included. In Diabetes *Edutool* Questionnaire 1 and Diabetes *Edutool* Questionnaire 2 there were theoretically based questions that were exactly the same in both questionnaires. This was done to assess the increase in the number of learners correctly answering the questions after watching the quick-start guide presentation and doing the insulin question on the *Edutool*. The comparison between the results of each question and an overall test score comparison will be included.

Primary school trial results

Diabetes Edutool Questionnaire 1

This questionnaire is given in Appendix A.1. The open-ended questions are presented in Table 4. All results are expressed as a percentage of the total number of participants.

Table 4: Summary of open-ended questions in Questionnaire 1 for primary school trial.

Gender	Male	Female
	52.94%	47.06%
Age (years)	12	13
	5.88%	94.12%
Do you have a close friend or family member with diabetes?	Yes	No
	52.94%	47.06%

There were eight females and nine males in the class of 17, and 16 of them were 13 years old. At this age, it was not expected that the participants would have significant knowledge on the subject matter. The exception would be if a learner had a close friend or family member with diabetes.

There were nine participants that indicated that a close friend or family member had diabetes. This might be either type 1- or type 2 diabetes. As the software is only relevant to type 1 diabetes, the results obtained are inconclusive.

The participants were also asked two questions regarding their computer use and skill level. If a participant has never used a computer before, the software would be impossible to use; therefore he or she might find it difficult to use the *Edutool*. This might induce an anomaly in the results obtained regarding the ease-of-use of the program.

The results for the first question regarding computer use are presented in Table 5.

Table 5: Computer use question.

How often do you use a computer?			
Every day	A few times a week	Once a month	Never
41.18%	58.82%	0.00%	0.00%

From the results it could be seen that seven participants used a computer every day, and ten used it a few times a week. The next question regarding the computer use was asked to determine the skill level of the user. This question's results were divided according to the results in Table 5: 'everyday' users and 'a few times a week' users. These results are presented in Table 6 and Table 7.

Table 6: 'Everyday' users: difficulty of task question.

'Everyday' users: (N = 7)			
Difficulty of task:			
Games	Internet	School projects	Scientific programs
0.00%	14.29%	71.43%	14.29%

Table 7: 'A few times a week' users: difficulty of task question.

'A few times a week' users: (N = 10)			
Difficulty of task:			
Games	Internet	School projects	Scientific programs
0.00%	10.00%	60.00%	30.00%

From the two tables it is evident that the majority of participants in both groups use a computer for school projects. This might include the use of most of the Microsoft Office[®] programs (Word[®], Excel[®], etc.). Therefore, the skill level of the participants was regarded as sufficient to be able to easily use the software presented in the trial.

Theory-based questions

The closed-ended questions were chosen to determine the knowledge level of the participant on the subject matter: BG and diabetes. These questions were numbered 6 – 18 in both the Diabetes *Edutool* Questionnaire 1 (pre-trial questionnaire) and the Diabetes *Edutool* Questionnaire 2 (post-trial questionnaire). The results for each question are presented as a percentage of participants that answered the specific question correctly.

Table 8: Results of theory-based questions in the pre-trial questionnaire in the primary school trial.

Question number	Percentage correct
6	76.47%
7	47.06%
8	52.94%
9	94.12%
10	29.41%
11	70.59%
12	76.47%
13	100.00%
14	70.59%
15	58.82%
16	70.59%
17	29.41%
18	41.18%

From Table 8 it can be concluded that the knowledge level of the participants varied from high to low depending on the question. For example, the only question that everybody answered correctly was Question 13. This question was as follows:

13. Which beverage will raise the blood glucose of a person with type 1 diabetes the least?

glass of milk	coffee with sugar	can of cola	glass of soda water
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The questions that scored the lowest were Questions 10 and 17. In both cases, only five of the 17 learners answered correctly. The full questionnaire is shown in Appendix A.

The results are also presented in a bar graph format to ease the readability of the comparison between the results for each question. This is depicted in Figure 41:

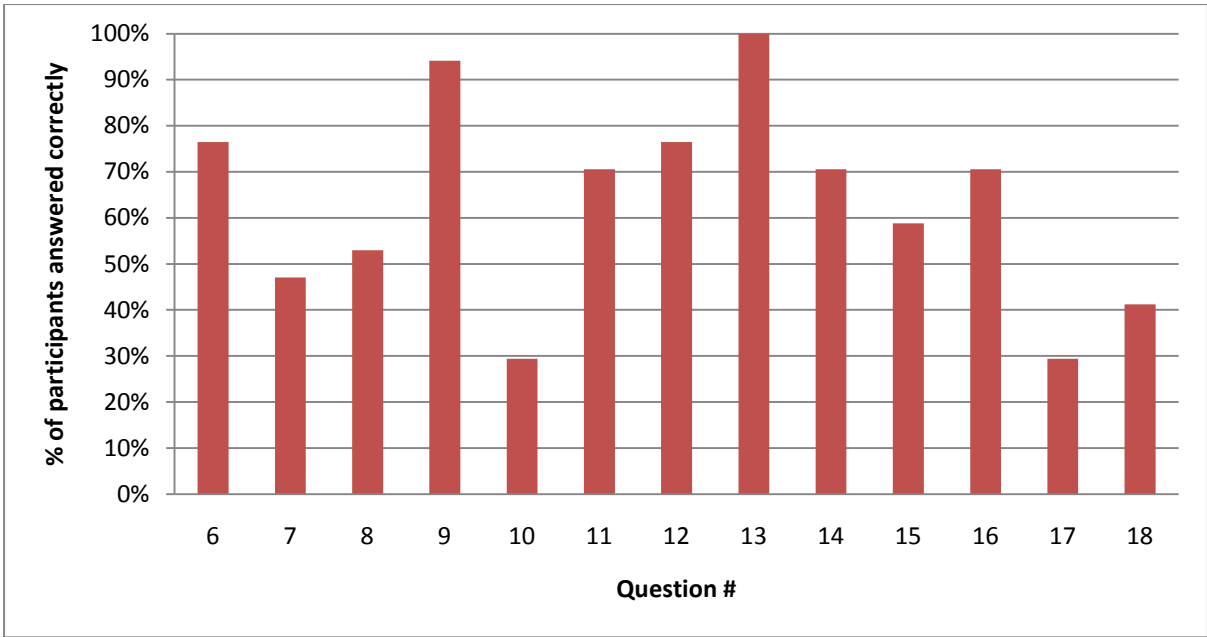


Figure 41: Results of theory-based questions in the pre-trial questionnaire in the primary school trial.

Summary of total test scores

The total scores for each participant for Diabetes Questionnaire 1 are listed in Table 9. These numbers refer to an individual computer that was randomly selected by the learner. This was only done to distinguish between the results of the participants. The average test score for the group is also given.

The highest test score was 100% and the lowest 38.46%. The mean test score was 62.9% with a standard deviation of 18%. The statistical analysis is included in Appendix C.

There were five participants that scored higher than 75%, and all of these participants indicated that they had a close friend or family member with diabetes. This could indicate that they had previous knowledge on the subject.

Table 9: Total test scores for primary school trial participants for the pre-trial questionnaire.

Participants	Total test score
1	84.62%
2	53.85%
3	76.92%
4	84.62%
5	46.15%
6	69.23%
7	46.15%
8	46.15%
9	69.23%
10	46.15%
11	69.23%
12	61.54%
13	38.46%
14	38.46%
15	61.54%
16	76.92%
17	100.00%
Average	62.90%

Diabetes Edutool Questionnaire 2

After watching the quick-start guide presentation, the participants were asked to complete an analytical insulin-related question by using the *Edutool*. The question was as follows:

Arnold has a starting blood glucose value of 8 mmol/L.

He is hungry and eats a medium burger.

Afterwards he goes for a 20-minute run.

Question: How much insulin must Arnold use to lower his blood glucose to 5 mmol/L after the burger and exercise?

The participants all answered the question correctly (i.e. 5 U). This led to the conclusion that primary school learners understood the presentation regarding diabetes and the *Edutool*, and found the software sufficiently straightforward to answer the question.

This was the first proof that the *Edutool* could be used as an educational tool to teach non-diabetic people about diabetes, and how external and internal disturbances influence the BGL of a person.

Open-ended questions

Several questions regarding the ease-of-use of the software and understanding of diabetes were asked. These questions are shown in Diabetes *Edutool* Questionnaire 2, Appendix A.2. The ease-of-use questions will be discussed first. The results for these questions are presented in Table 10.

Table 10: Open-ended questions regarding *Edutool* in the primary school trial.

How did you find the Edutool program to use?				
Very easy	Easy	I Managed	Difficult	Very Difficult
70.59%	23.53%	5.88%	0.00%	0.00%
How did you find the food and exercise database to use?				
Very easy	Easy	I Managed	Difficult	Very Difficult
58.82%	35.29%	5.88%	0.00%	0.00%
How did you find using the arrows (e.g. dragging them)?				
Very easy	Easy	I Managed	Difficult	Very Difficult
58.82%	23.53%	11.76%	5.88%	0.00%

These results are also presented schematically in Figures 42 and 43. Figure 42 presents the participants' ratings of the ease-of-use of the program. The exact values for each rating are given in Table 10.

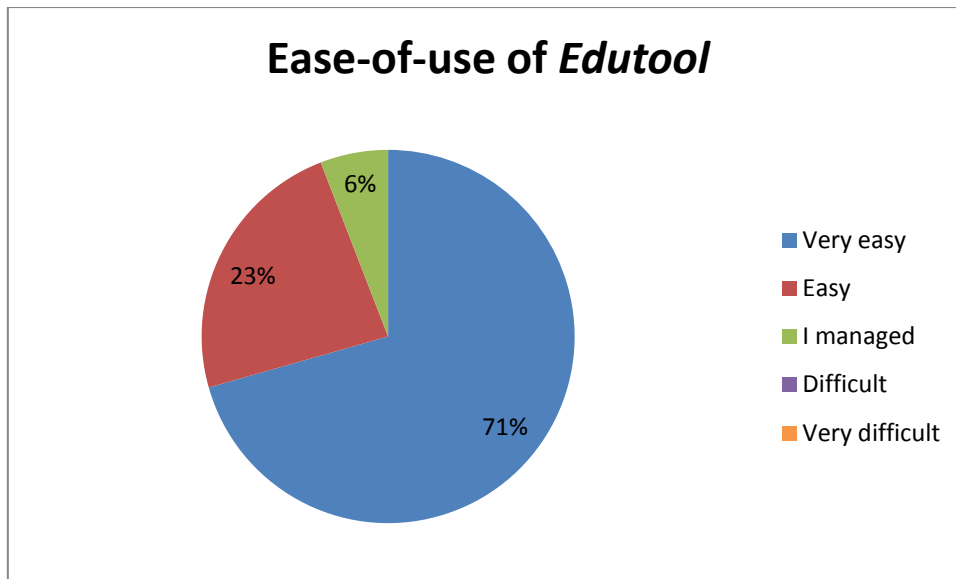


Figure 42: Percentage of participants in the primary school trial rating the ease-of-use of the *Edutool*.

Figures 43 (a) and (b) show the ease-of-use of the databases, and dragging the arrows in the *Edutool*, respectively. Each colour in the pie chart represents the percentage of participants rating the function within the program.

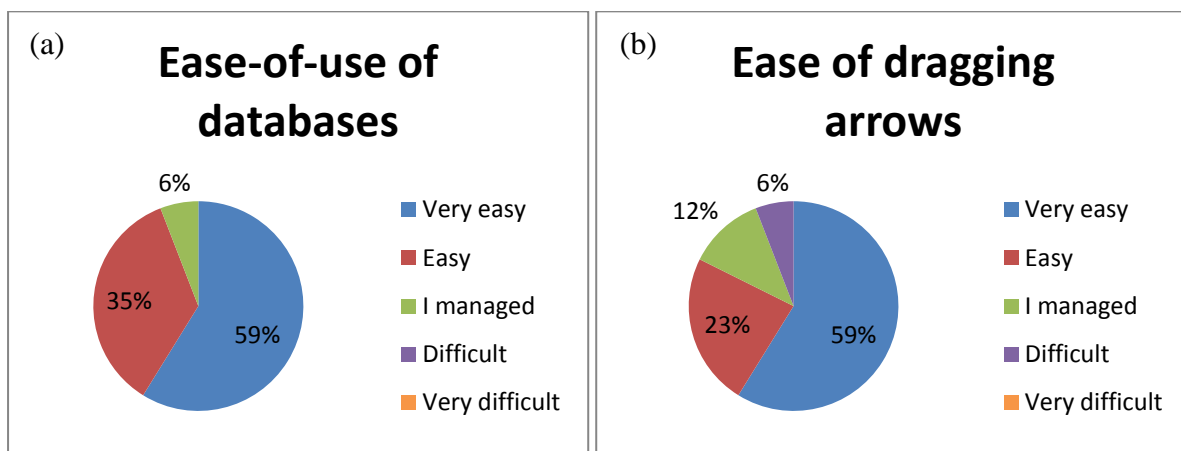


Figure 43: Ease-of-use of (a) the databases within the *Edutool* and (b) dragging the arrows on the main user interface of the *Edutool*.

Theory-based questions

The theory-based questions were the same as the questions asked in the pre-trial questionnaire. The results for each question are listed in Table 11.

Table 11: Results of theory-based questions in the post-trial questionnaire in the primary school trial.

Question number	Percentage correct
6	94.12%
7	100.00%
8	100.00%
9	100.00%
10	100.00%
11	76.47%
12	100.00%
13	52.94%
14	94.12%
15	70.59%
16	70.59%
17	94.12%
18	94.12%

From Table 11 it is evident that five of the 13 questions were answered correctly, whereas only one participant answered incorrectly with four of the questions. This is a definite improvement in the results compared to the pre-trial questionnaire. This comparison will be discussed later in this chapter.

Summary of total test scores

The total test scores are listed in Table 12, with the average given at the end of the table. The average of the total test scores for Diabetes Questionnaire 2 was 88.24% with a standard deviation of 11.89%.

The participants remained at the same numbered computer throughout the trial, but the numbers listed below for each participant is not the same as for Diabetes *Edu*tool Questionnaire 1. These numbers were used to ease the presentation of the results.

Table 12: Total test scores for each post-trial questionnaire participant in the primary school trial.

Participants	Total test score
1	100.00%
2	100.00%
3	92.31%
4	92.31%
5	84.62%
6	76.92%
7	92.31%
8	76.92%
9	76.92%
10	69.23%
11	92.31%
12	92.31%
13	61.54%
14	92.31%
15	100.00%
16	100.00%
17	100.00%
Average	88.24%

Diabetes Questionnaire 3

After completion of Diabetes *Edutool* Questionnaire 2, the participants were asked to work on the AIDA simulator and try to complete a similar insulin-related question as the one asked in Diabetes *Edutool* Questionnaire 2. The question could not be answered by any of the participants, since the AIDA simulator is not an integrated model. Therefore, it does not have an exercise database from where exercise can be selected. The AIDA simulator is one of the most salient educational simulation models worldwide and was chosen for comparison to the *Edutool* for this reason.

The AIDA software used during the trial is the newest version available, AIDA v4.3b. The program runs with MS-DOS[®], which is a very old operating system and much more difficult to use than Microsoft Windows[®]. A mouse cannot be used to navigate within the program. The Tab button on the computer keyboard is used to move from one input box to the next.

The primary school learners found this program confusing and very difficult to understand, as is evident from the open-ended questions in Diabetes Questionnaire 3. The results for these questions are presented in Table 13.

Table 13: Open-ended questions regarding the AIDA software in the primary school trial.

How did you find the AIDA program to use?				
Very easy	Easy	I managed	Difficult	Very difficult
0.00%	0.00%	0.00%	0.00%	100.00%
Would you recommend the AIDA simulator to your friends or family?				
Yes			No	
0.00%			100.00%	

All participants indicated that the AIDA simulator was very difficult to use and that they would not recommend the program to family and friends. When asked which of the two diabetes simulators they preferred, all participants indicated *EduTool*.

Comparison between pre- and post-trial questionnaire results

A brief comparison between the individual question results will be given, followed by the overall test score comparison. The improvement in overall test scores will also be discussed.

Individual question comparison

There was a definite improvement in the percentage of participants that answered each question correctly in the post-trial questionnaire, with one exception. This can be seen in Figure 44.

The green bars represent the results for Diabetes Questionnaire 1, and the blue bars the results for Diabetes *EduTool* Questionnaire 2. There was one anomaly, namely Question 13. In Diabetes Questionnaire 1 this question acquired full marks, whereas after watching the presentation only 52.94% answered it correctly.

This may be due to various reasons; the most obvious assumption was that the learners were confused by the use of ‘teaspoons’ as a measuring unit during the quick-start guide presentation. Although it was clear that ‘teaspoons’ are used as the measuring unit for glucose and ‘units’ for insulin, this might have confused the learners.

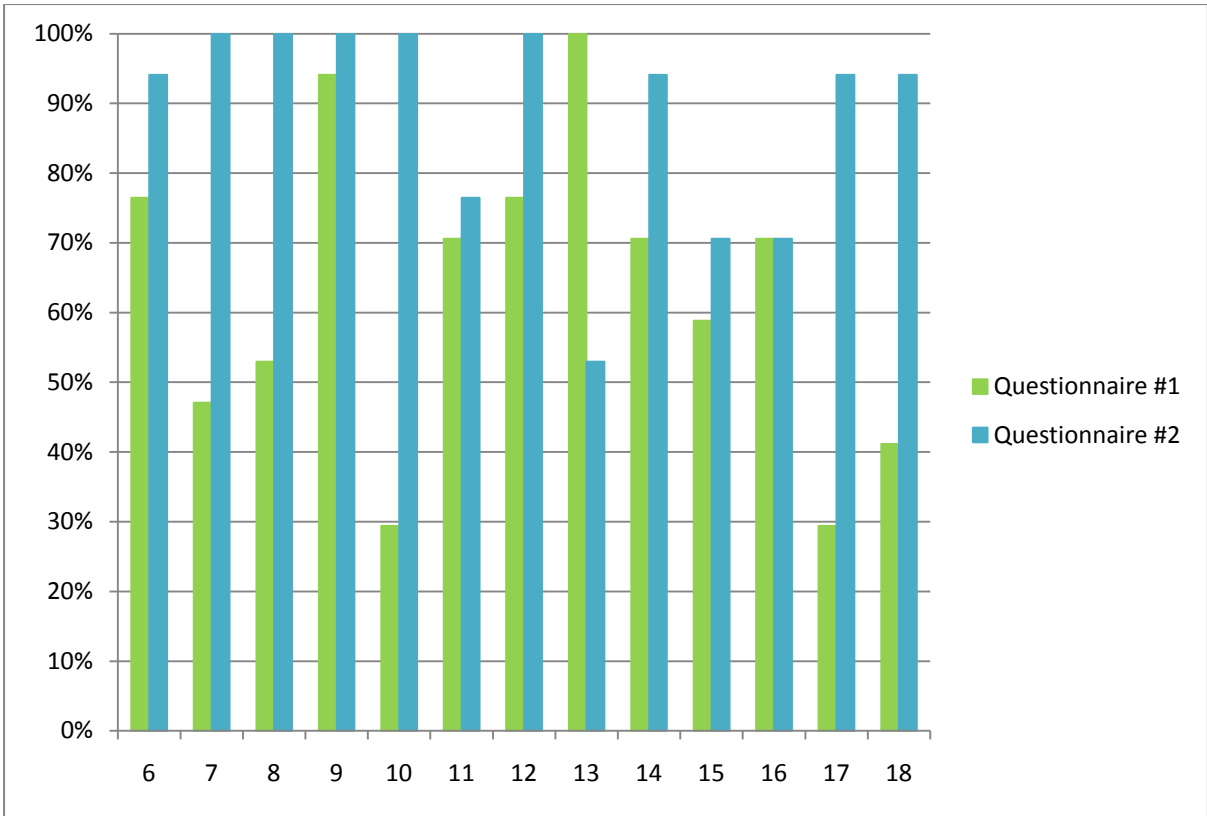


Figure 44: Comparison between results for individual questions in Diabetes *Edutool* Questionnaires 1 and 2 for the primary school trial.

Overall test score comparison

The average overall test scores for each questionnaire are listed in Table 14. The fold improvement is also included.

Table 14: Comparison between average total test scores in the primary school trial.

Average total test scores:	
Diabetes Questionnaire 1	62.90%
Diabetes Questionnaire 2	88.24%
Fold improvement*	0.40

*Fold improvement = (Questionnaire 2-Questionnaire 1)/Questionnaire 1

The average test score (88.24%) was significantly higher than the average for Diabetes Questionnaire 1 (62.9%). This increase indicated that the knowledge of all participants on BG and diabetes increased after watching the quick-start guide presentation and working on the *Edutool*.

The *p*-value (cf. Appendix C) for the dependent *t*-test for paired samples for this trial was determined as 0.000005. If $p < 0.05$, the increase in overall test score results from

questionnaire 1 to questionnaire 2 can be regarded as statistically significant. This is the case for the primary school trial as $p < 0.001$.

The main goal of repeating the same theory questions pre- and post-trial was to determine if the participant's scores would increase after the presentation and working on the *EduTool*. This would give an indication of the educational value of the *EduTool*.

The improvement was 0.4-fold, which is an improvement of 40% from the overall test results of Diabetes Questionnaire 1 to Diabetes Questionnaire 2. This is a significant increase in the knowledge of the participants. From the data presented in Table 14, it is evident that the knowledge of the participants had increased and therefore, the *EduTool* has fulfilled its goal as educational software.

Conclusion

From the results and discussion of the primary school trial, it can be concluded that the *EduTool* and the quick-start presentation have increased the knowledge of the participants of diabetes and BG by 40% ($p < 0.001$). This is a significant increase, and the *EduTool* has achieved its goal of educating non-diabetic people on this subject.

Secondary school trial

The protocol for the trial, and the order in which each task was completed, were the same as set out in the primary school trial section above. The results will be presented in this order, with the comparison between pre- and post-trial data given at the end.

Diabetes EduTool Questionnaire 1

The Diabetes *EduTool* Questionnaire 1 is given in Appendix A.1. The open-ended questions are presented in Table 15. All results will be expressed as a percentage of the total number of participants.

Table 15: Summary of open-ended questions in Diabetes *Edutool* Questionnaire 1 for secondary school trial.

Gender	Male		Female	
	50.00%		50.00%	
Age (years)	16	17	18	
	12.50%	62.50%	25.00%	
Do you have a close friend or family member with diabetes?	Yes		No	
	43.75%		56.25%	

The age distribution was from 16 – 18 years, with the majority of the participants 17 years of age. It was expected that the participants might have a higher level of knowledge on the subject at this age due to the learners having biology as subject choice in secondary school.

The level of knowledge might again be influenced by the number of learners that have a close friend or family member with diabetes. In contrast to the primary school participants, the majority of the participants did not have a friend or family member with diabetes.

The participants were also asked two questions regarding their computer use and skill level. If a participant has never used a computer, the software would be impossible to use and therefore he or she might find it difficult to use. This might induce an anomaly in the results obtained regarding the ease-of-use of the program.

The results for the first question regarding computer use are presented in Table 16:

Table 16: Computer use question.

How often do you use a computer?			
Everyday	A few times a week	Once a month	Never
50.00%	37.50%	12.50%	0.00%

From these results it could be seen that eight of the 16 participants used a computer every day, while six and two participants used a computer only a few times per week, or once a month, respectively. This indicated that the participants all knew how to use a computer. The next question was to assess the computer skill level they have.

In Table 17 to 19 the results for each group, namely, ‘everyday’ users, ‘a few times a week’ users and ‘once a month’ users are given in this respective order.

Table 17: ‘Everyday’ users: difficulty of task question.

‘Everyday’ users: (N = 8)			
Difficulty of task:			
Games	Internet	School projects	Scientific programs
12.50%	0.00%	37.50%	50.00%

Table 18: ‘A few times a week’ users: difficulty of task question.

‘A few times a week’ users: (N = 6)			
Difficulty of task:			
Games	Internet	School projects	Scientific programs
0.00%	0.00%	83.33%	16.67%

Table 19: ‘Once a month’ users: difficulty of task question.

‘A few times a week’ users: (N = 2)			
Difficulty of task:			
Games	Internet	School projects	Scientific programs
50.00%	0.00%	50.00%	0.00%

From the first two tables it is evident that the majority of participants in both these groups used a computer for either school projects or scientific programs. This might include the use of most of the Microsoft Office[®] programs (Word[®], Excel[®], etc.). Therefore, the skill level of the participants was regarded as sufficient to be able to easily use the software presented in the trial.

In the last group, 1 user only used the computer for games, and the other user for working in scientific programs. Thus, from all 16 participants only 1 might have a slight disadvantage in using a computer because his task difficulty included only playing games. Since this was such a small group in comparison to all the participants, the overall skill level was still regarded as sufficient.

Theory-based questions

The closed-ended questions were exactly the same as the questions used during the primary school trial. These questions were numbered 6 – 18 in both Diabetes *Edutool* Questionnaire 1 (pre-trial questionnaire) and Diabetes *Edutool* Questionnaire 2 (post-trial questionnaire). These results are presented in Table 20.

Table 20: Results of theory-based questions in the pre-trial questionnaire in the secondary school trial.

Question number	Percentage correct
6	100.00%
7	50.00%
8	75.00%
9	87.50%
10	50.00%
11	93.75%
12	68.75%
13	31.25%
14	62.50%
15	68.75%
16	56.25%
17	68.75%
18	25.00%

From Table 20 it can be concluded that the knowledge level of the participants varied from high to low depending on the question. For example, the only question that everybody had correct was Question 6. This question asked whether glucose was a simple sugar, simple protein, simple fat or simple hormone. The participants might have learned this in chemistry, biology, by reading educational books or by general knowledge.

Questions 18 scored the lowest. Only four learners answered this question correctly. These questions are given in Appendix A.

The results are also presented in a bar graph format (Figure 45) to ease the readability of the comparison between the results for each question.

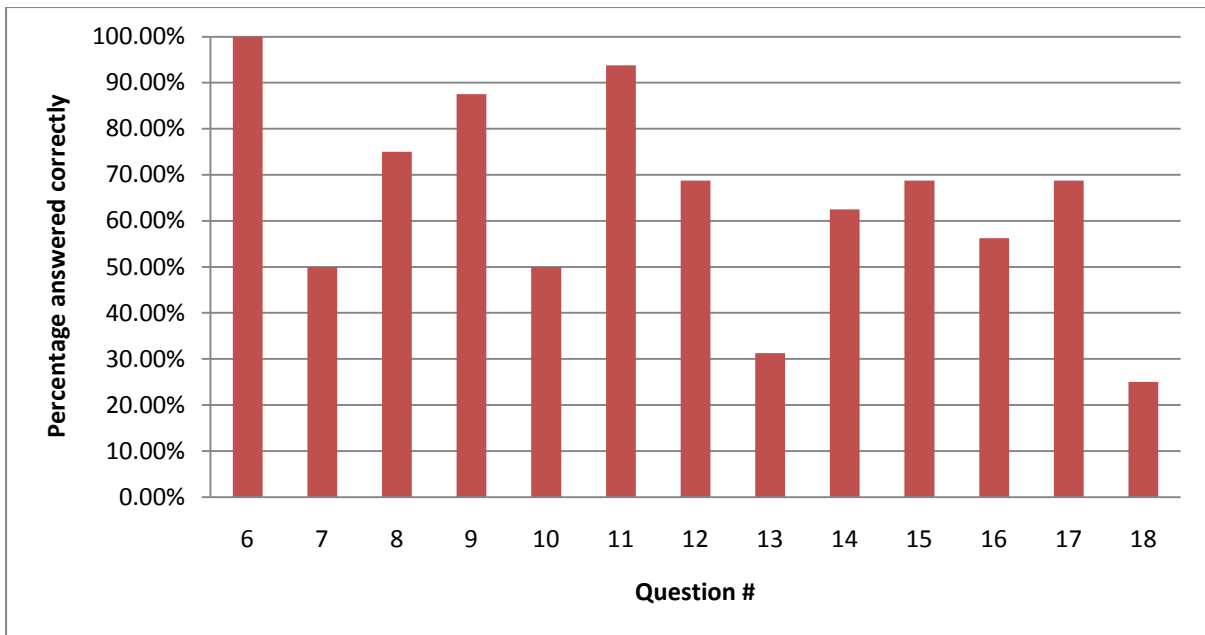


Figure 45: Results of theory-based questions in the pre-trial questionnaire in the secondary school trial.

Summary of total test scores

The total scores for each participant's Diabetes *Edutool* Questionnaire 1 are listed in Table 21. The results are numbered according to the same method as discussed for the primary school trial. The average test score for the group is also given.

The highest score in this group was 84.62% and the lowest score 38.46%. During the primary school trial 1 participant received a 100% score for this questionnaire. This is higher than the highest score obtained by a participant four years his/her senior.

The mean score for the group was 64.42% with a standard deviation of 13.14%. This average score was only slightly higher than the average score obtained by the primary school group (62.9%). A larger difference between the baseline data of the two groups was expected.

This deduction has only a small basis, namely that as secondary school learners the group should have encountered the subject of BG and diabetes sometime during their four years in high school. However, this deduction is impossible to prove without compromising the randomness of the trial. It is also possible that this can be explained by the small sample group.

Table 21: Total test scores for each participant for the pre-trial questionnaire in the secondary school trial.

Participants	Total test score
1	53.85%
2	38.46%
3	61.54%
4	61.54%
5	76.92%
6	61.54%
7	76.92%
8	76.92%
9	76.92%
10	76.92%
11	46.15%
12	53.85%
13	61.54%
14	84.62%
15	53.85%
16	69.23%
Average	64.42%

Diabetes Edutool Questionnaire 2

After viewing the quick-start guide presentation, the participants were asked to complete an analytical insulin-related question by using the *Edutool*. The question was the same as the question asked during the primary school trial.

In comparison with the primary school trial, where all participants answered the question correctly, 1 participant in this group did not answer the question correctly. This might be because the learner did not understand the question, did not read it thoroughly or found the *Edutool* difficult to use.

The majority of the group answered it correctly. The deduction can again be made that the *Edutool* quick-start guide and simulator had educational value and taught the participants about diabetes and BG. This deduction will be further proven in the following sections.

Open-ended questions

Several questions regarding the ease-of-use of the software and understanding of diabetes were asked. These questions can be seen in Diabetes *Edutool* Questionnaire 2 in Appendix A.2. The ease-of-use questions will be discussed first. The results for these questions are presented in Table 22.

Table 22: Open-ended questions regarding *Edutool* in the secondary school trial.

How did you find the Edutool program to use?				
Very easy	Easy	I managed	Difficult	Very difficult
56.25%	12.50%	12.50%	12.50%	0.00%
How did you find the food and exercise database to use?				
Very easy	Easy	I managed	Difficult	Very difficult
87.50%	6.25%	6.25%	0.00%	0.00%
How did you find using the arrows (e.g. dragging them)?				
Very easy	Easy	I managed	Difficult	Very difficult
37.50%	43.75%	6.25%	0.00%	0.00%

These results are also presented schematically in Figures 46 and 47. Figure 46 presents the participant's ratings of the ease-of-use of the program. The exact values in each rating are given in Table 22.

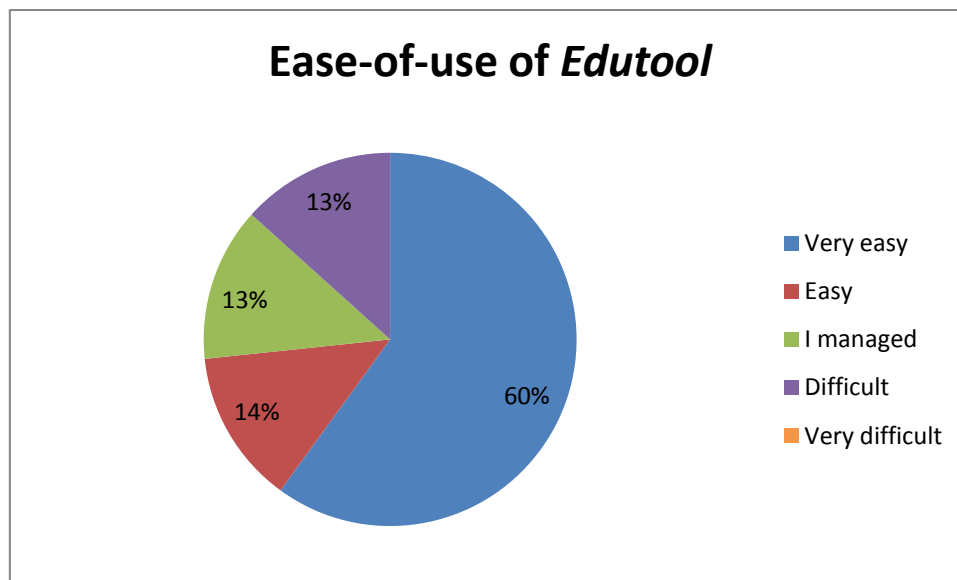


Figure 46: Percentage of participants in the secondary school trial rating the ease-of-use of *Edutool*.

The next two graphs present the ease-of-use of the databases, and dragging the arrows in the *Edutool*, respectively.

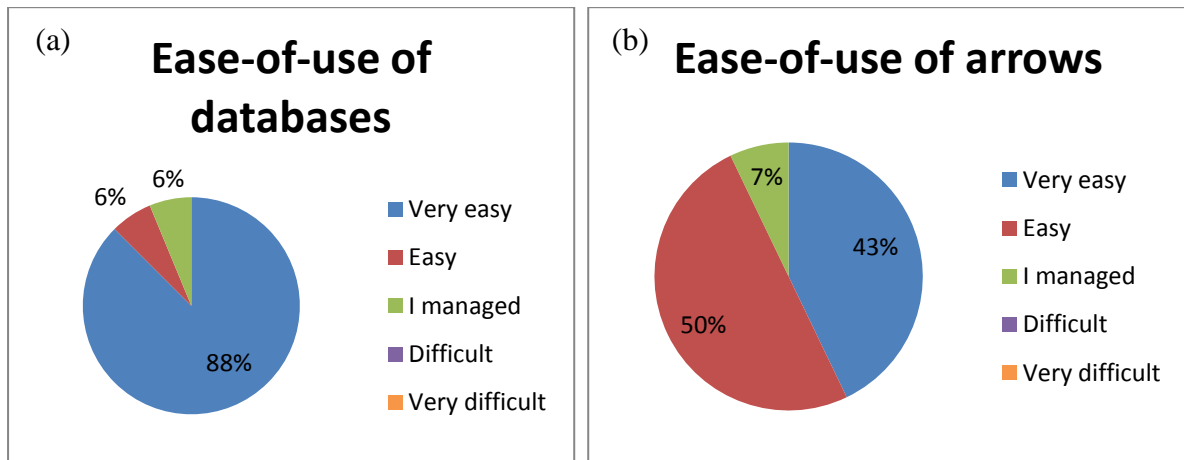


Figure 47: Ease-of-use of (a) the databases within the *Edutool* and (b) dragging the arrows on the main user interface of the *Edutool*.

In contrast with the primary school trial, several of the secondary school learners did not find the arrows on the main user interface as user-friendly. One participant rated the ease-of-use of the *Edutool* as difficult. This group of learners rated the databases as very easy to use.

Theory-based questions

The theory-based questions were the same as the questions asked in the pre-trial questionnaire. The results for each question are listed in Table 23:

Table 23: Results of theory-based questions in the post-trial questionnaire in the secondary school trial.

Question number	Percentage correct
6	93.75%
7	100.00%
8	68.75%
9	93.75%
10	100.00%
11	93.75%
12	81.25%
13	87.50%
14	93.75%
15	68.75%
16	56.25%
17	100.00%
18	93.75%

From Table 23 it can be seen that three of the 13 questions received full marks, whereas the lowest scoring participant answered four of these questions incorrectly. This is a definite improvement in the results compared to the pre-trial questionnaire. This comparison will be discussed further later in this chapter.

Summary of total test scores

The total test scores are listed in Table 24, with the average given at the end of the table. The average for the total test scores of Diabetes *Edutool* Questionnaire 2 was 87.02% with a standard deviation of 9.62%.

Table 24: Total test scores for each post-trial questionnaire participant in the secondary school trial.

Participants	Total test score
1	76.92%
2	76.92%
3	84.62%
4	84.62%
5	84.62%
6	76.92%
7	84.62%
8	84.62%
9	84.62%
10	92.31%
11	100.00%
12	100.00%
13	100.00%
14	100.00%
15	69.23%
16	92.31%
Average	87.02%

It must be noted that the average total test score for the secondary school group was lower than the primary school average total test score (88.24%). This difference is very small, but it would still be expected for the secondary school group, due to their age, to fare better.

Diabetes Questionnaire 3

After completion of Diabetes *Edutool* Questionnaire 2, the participants were asked to work on the AIDA simulator and try to complete a similar insulin-related question as the one asked in Diabetes *Edutool* Questionnaire 2. The question could not be answered by any of the participants.

The secondary school learners found this program confusing and very difficult to understand, as is evident from the open-ended questions in Diabetes Questionnaire 3. The results for the ease-of-use of the simulator question are shown in Figure 48. The majority found the program either 'very difficult' or 'difficult' to use, whereas two learners could manage within the program. This may be because several of the learners have seen an MS-DOS[®] operating system and know how to navigate within it.

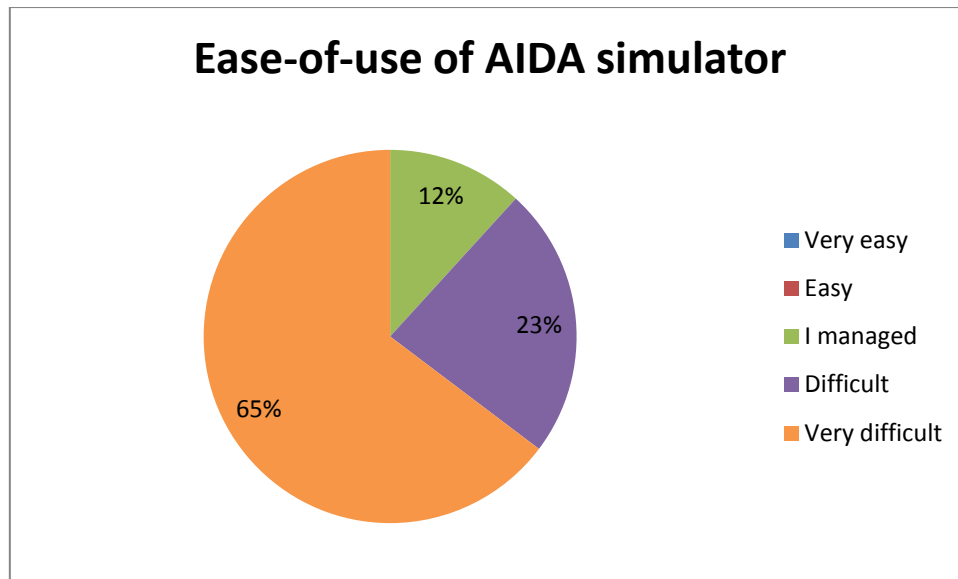


Figure 48: Results of the ease-of-use of the AIDA simulator in the secondary school trial.

When asked if any participant would recommend the AIDA simulator to friends or family, three of the 16 answered 'yes'. However, when asked which program they preferred, all participants voted for the *Edutool* diabetes simulator. This again shows the success of the presentation and simulator in educating the participants on diabetes and BG.

Comparison between pre- and post-trial questionnaire results

Individual question comparison

There was a definite improvement in the percentage of participants that answered each question correctly in the post-trial questionnaire, with two exceptions. This can be seen in Figure 49.

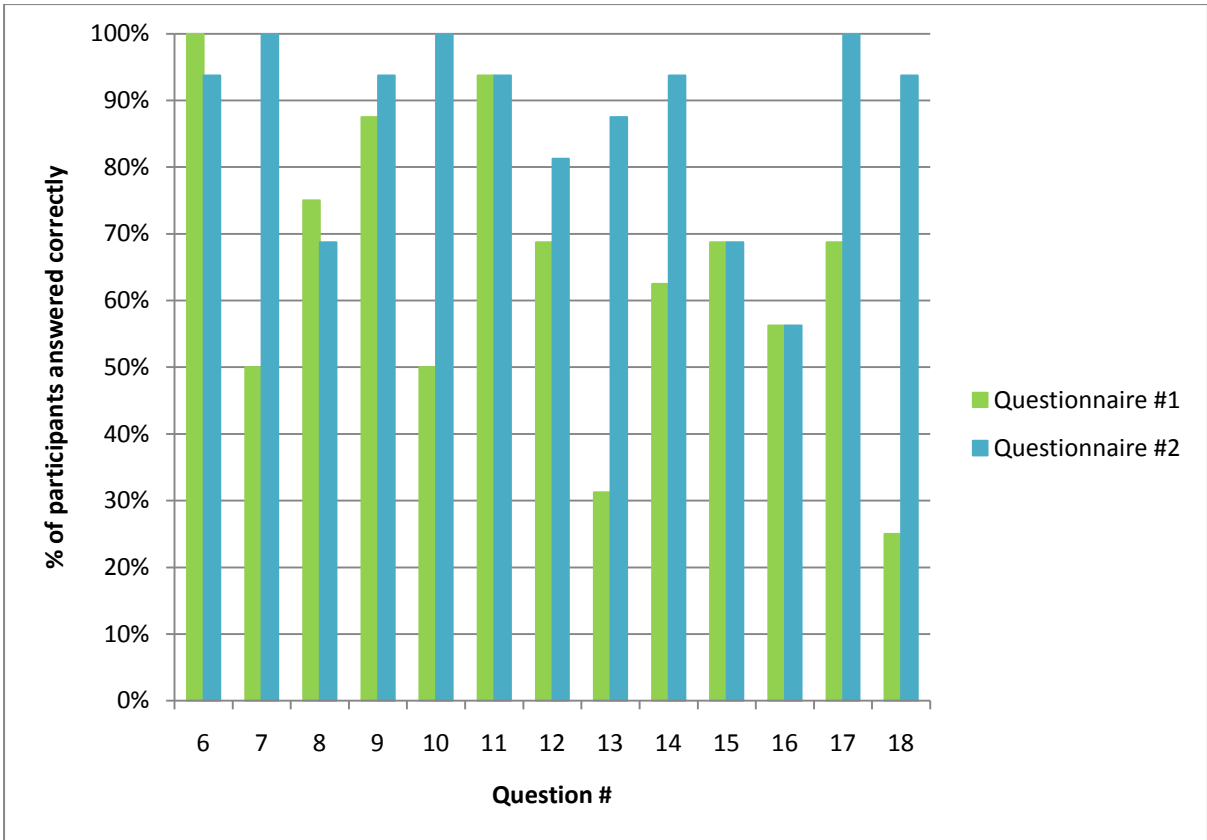


Figure 49: Comparison between results for individual questions in Diabetes Questionnaire 1 and 2 for the secondary school trial.

Two anomalies occurred with Questions 6 and 8. This might be due to the presentation being confusing to the participants, although this is unlikely since the primary school trial did not have the same anomalies for the same questions. It would be expected that if the primary school participants were confused by a certain question, the same would happen in the secondary school trial.

Another possible explanation is that in Diabetes Questionnaire 1, the participants guessed the answers to these questions correctly, and did not learn the answer when they watched the presentation. This indicates that a select few participants did not pay attention during the presentation, since only one extra participant answered these specific questions incorrectly the second time around.

Overall test score comparison

The average overall test scores for each questionnaire are listed in Table 25. The fold improvement is also included.

Table 25: Comparison between average total test scores in the secondary school trial.

Average total test scores:	
Questionnaire 1	64.42%
Questionnaire 2	87.02%
Improvement	0.35

*Fold improvement = (Questionnaire 2 - Questionnaire 1)/Questionnaire 1

The average test score (87.02%) was significantly higher than the average for Diabetes Questionnaire 1 (64.42%). This increase indicated that the knowledge of all participants on BG and diabetes increased after viewing the quick-start guide presentation and working on the *Edutool*.

The *p*-value for the secondary school trial is 0.000015, which indicates that the increase in overall test scores from pre-trial to post-trial is statistically significant. Refer to Appendix C for calculations.

The improvement is 0.35-fold, which indicates an improvement of 35% from the overall test results of Diabetes *Edutool* Questionnaire 1 to Diabetes *Edutool* Questionnaire 2. This is a significant increase in the knowledge of the participants, although it is lower than the 0.4-fold increase for the primary school trial. This is expected, since it is plausible for the secondary group to have a higher baseline knowledge level.

From the data presented in Table 25, it is evident that the knowledge of the participants had increased and therefore the *Edutool* has reached its target as educational software.

Conclusion

The results presented above indicate a definite improvement in the knowledge of the participants on diabetes and blood glucose. Therefore, it is concluded that the *Edutool* diabetes simulator, in conjunction with the quick-start guide presentation succeeded in improving the education of the secondary school participants.

5.7 Conclusion

The questionnaire development and validation, the protocol for the trials, the trials itself, and finally the results and discussion were included in this chapter. The final results indicated a

40% and 35% improvement in the participants' knowledge for the primary and secondary school trials, respectively ($p < 0.001$).

This shows that the quick-start guide presentation and *Edutool* diabetes simulator have educated both groups on the subject of diabetes and BG. This was set out as the main objective of these trials. Therefore, it can be concluded that the validation of the educational value of the *Edutool* was a success.

None of the participants recommended the AIDA simulator when asked which of the two programs they would prefer. This is a clear indication of the success of the *Edutool's* ease-of-use, aesthetic value and basic features.

5.8 References

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