Summative Evaluation of the Antibiotic Information App

Bachelor thesis

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Abstract

Nurses have important tasks regarding medication and antibiotics. Physicians prescribe the medication, but nurses need to give the correct dosage. They are close to the patient and are the first to notice differences in a patients status. Nurses receive a lot of information from many different devices, including a lot of information that has to do with Antibiotic Stewardship. Antibiotic Stewardship programs try to optimize the use of antibiotics in order to control antibiotic resistance, which is caused by wrong or careless use of antibiotics. All this information could lead to a cognitive overload for nurses, and integrated information could be a solution. Therefore, an antibiotic information app was designed for nurses, to help them with their information needs. This research tested whether the app was effective and supportive for nurses. Nurses needed to solve three scenarios with or without the app. The scenarios contained situations and questions that could arise during their job. There were three conditions, a baseline measurement without the app, and two post-measurements 8 months after the first measurement, one post-measurement with and one post-measurement without the app. During these months, the app was available for all nurses. The expectation was that the effectiveness of the app was positively evaluated and that it would be easier for nurses to find information with than without the antibiotic app. The results of this research were not conclusive. It was ambiguous whether nurses did found more correct solutions, but it seemed to be that nurses were more satisfied with the app than with the other resources. It was not clear whether the app supported nurses to find the solution in less time, nor whether the app contributed to Antibiotic Stewardship, which meant that further research was needed.

Introduction

Nurses are very important because they are close to the patient all the time. When the physician is not around, nurses are the ones who notice differences in a patient's status. Koch et al. (2012) have observed five frequent task categories which nurses fulfill: communication, medication management, patient awareness, organization and direct patient care. Doctors prescribe medication, but nurses prepare antibiotics and medication and give these to the patient. They need to give the right dosage, also if there are changes in a patients status. This shows the importance of the tasks of nurses. It is important to give antibiotics with the right dosage, it will contribute to the problem of antibiotic resistance if antibiotics are mis- or overused (MacDougall & Polk, 2005). Careless or wrong use of antibiotics causes antibiotic resistance. This is a problem because despite the critical need for new antibiotics, the development of these is declining (Spellberg et al, 2004). So possibilities that patients get infected by a resistant bacteria increase and treating this is hard because there are less antibiotics which are effective. Wrong use of antibiotics has disadvantages for the patient, like more complications and more side-effects.

Antibiotic stewardship

Antibiotic Stewardship Programs are used to prevent wrong or careless use of antibiotics. These programs aim to optimize antibiotic use in order to control antibiotic resistance. This happens by only giving antibiotics when it is really necessary because by doing this, antibiotics stay effective and patients can get an optimal treatment (Kaki et al, 2011). The use of antibiotics can be optimized in four ways, firstly by giving the right dosage to the patient, not too much and not too little because by doing this, the antibiotic can work optimally with the smallest risk of resistance development. Secondly, give patients a small-spectrum antibiotic as fast as possible because when the cause is known, the pathogen can be tackled more effective. Thirdly, by making sure that patients will get antibiotics as long as necessary, but no longer. The more time antibiotics are used, the higher the chance to develop antibiotic resistance becomes. Lastly, give patients oral instead of intravenous administration as soon as possible because an infusion increases the chance of infections and without an infusion, patients are allowed to go home more quickly (Karreman et al., 2010). Nurses have an executive, controlling, observing and alarming role in antibiotic stewardship and they need a lot of information about antibiotics to do this well. This information needs to be easily accessible to perform antibiotic tasks as optimal as possible.

Tasks of nurses

Nurses need information about antibiotics to recognize critical moments or problems at the patient. This includes information about the disease of the patient, other potential medicines the patient's taking, etc. Besides information about antibiotics, there are more things nurses need to let them do their job. Collaboration is a key factor in hospitals and in intensive care units (ICU) and collaborative communication contributes to collaboration (Boyle & Kochinda, 2004). This is associated with positive nurse, patient and physician outcomes and Boyle & Kochinda have shown that collaborative communication can be improved. Positive nurse outcomes include enhanced professional relationships, increased satisfaction and lower turnover. Positive physician outcomes include enhanced learning and professional relationships and research utilization. So collaborative communication is important because it helps nurses doing a better job. Clinical decision support systems (CDSS) are important too. CDSS's improve health care outcomes and reduce preventable medical adverse events (Yuan, Finley, Long, Mills & Johnson, 2013). A CDSS is an application that analyzes data (for example provides a huge knowledge base) to help nurses and doctors with clinical decisions. This is an example to show what technology can do for nurses. The interoperable technology solutions could improve patients' safety and outcomes for nurses and reduce errors. So CDSS's support decisions, but the effectiveness of CDSS depends on the implementation and usability in complex health care situations.

Information integration and integrated displays

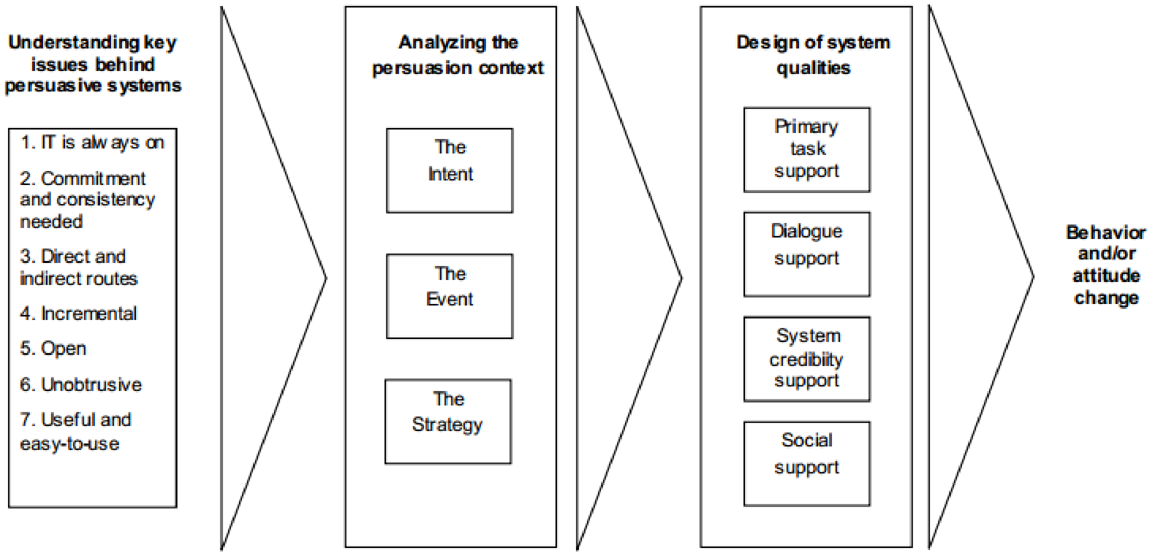
Information integration at the bedside may improve nurses' situational awareness (SA) of the patient and decrease errors and improve safety of the patient in the future (Koch et al., 2012). The workload of nurses is high, they are engaged in more than one task frequently. They need to be aware of patients' treatment goals, are responsible for the monitoring and check changes in physiological functions, need to document their work, give medications and provide care coordination. All information about these things contributes to information overload and this contributes to cognitive overload when nurses try to integrate all these information. If cognitive load increases because of the information overload, the risk of errors increases too. So information needs to be organized to prevent cognitive overload. One way to support nurses at ICU's is to use integrated displays. Integrated displays have a high level of information integration and system level aggregation of information. Integrated displays decrease cognitive load and improve decision-making but integrated information displays are rarely available in the medical domain. Information and communication technology (ICT) increases access to information and provides other forms of support remotely (While & Dewsbury, 2010). Technology can support in health care situations but technology has to support nurses instead of causing more barriers. According to Stevenson et al. (2010), nurses reported that the actual computer systems were slow, illogical, complicated and unreliable. Nurses were unsatisfied with the electronic patient record because this did not support nursing practice. This was due to a lack of availability which undermined patient safety. They suggested that nurses must become involved in the future design and development of the electronic patient record. But the study of While & Dewsbury also shows positive results for the use of technology in health care situations (2011). For example, it enables new services like virtual health promotion sessions and it enables better personalized care planning and care coordination. So technology can be very useful, but it has to be a positive addition.

Persuasive technology

Information integration could be a solution, but other strategies about the designs of technology could be helpful too. Persuasive technology is interactive information technology designed for changing users' attitudes or behavior (Fogg, 2003) and could support nurses too. Behavior change support systems (BCSS) are information systems designed to form, alter or reinforce attitudes or behaviors or both without using coercion or deception (Oinas-Kukkonen, 2010), and have something in common with persuasive technology. The Persuasive System Design model developed by Oinas-Kukkonen and Harjumaa (2009) shows that the development of Persuasive systems consists of three steps, as shown in figure 1.

Figure 1

Persuasive System Design Model



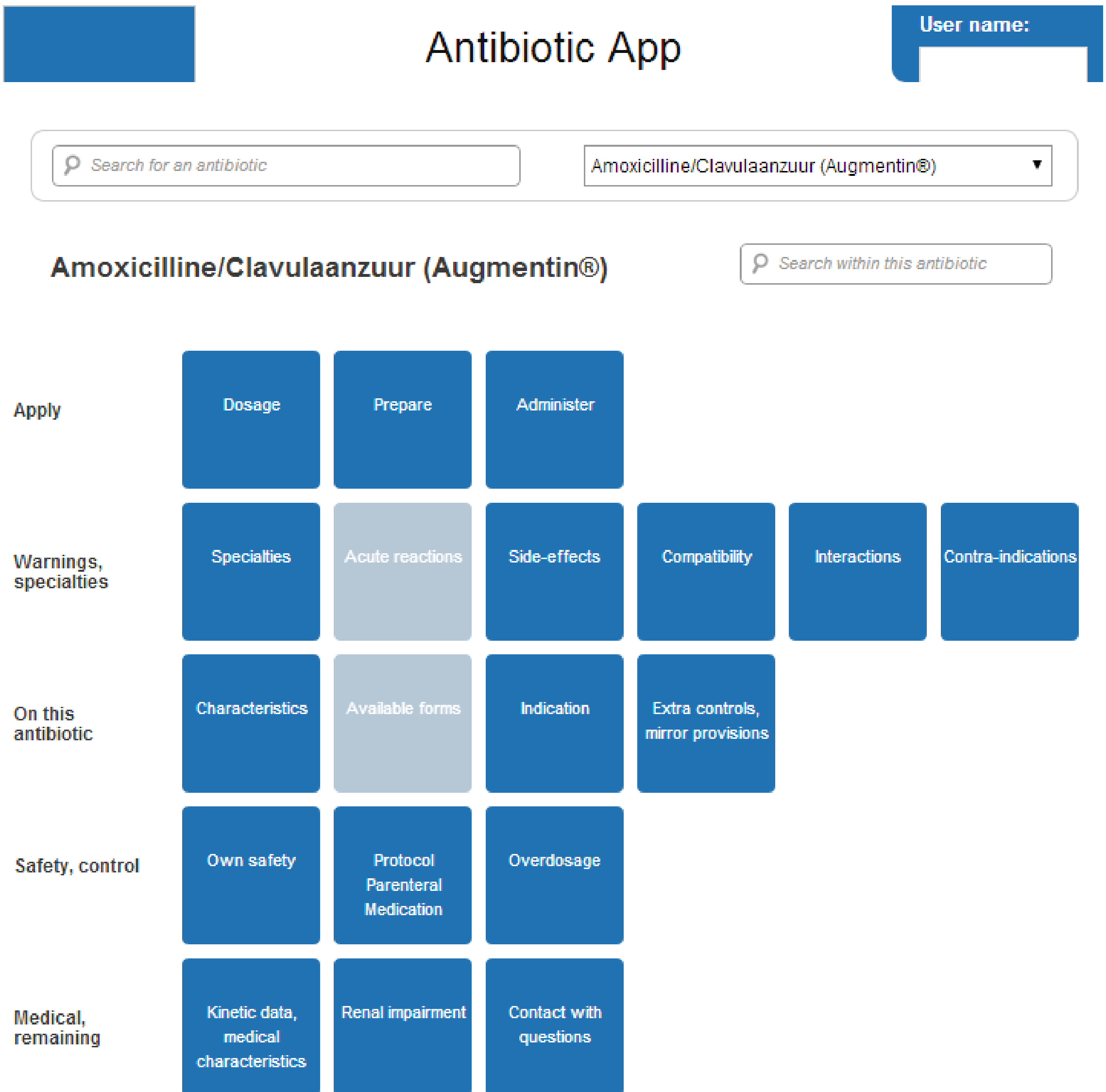
This model suggested design principles consisted of four categories, especially task support principles were important for this research. These principles relate to how to design a system so that it is more believable and therefore more persuasive. Reduction and tunneling are important principles in primary task support. The principle of reduction includes reducing complex behaviour into simple tasks, which helps users perform the target behavior. Tunneling includes guiding users through a process or experience which provides opportunities to persuade along the way. These are important principles to take into account when developing an app or another technological display because primary task support is the most important part in such displays. When reduction and tunneling are well applied, this will lead to better performances.

Antibiotic information app

Nurses gather information from different information systems, have to integrate this information and have to decide whether further action is required. There are many applications to support health care workers, both websites and mobile applications (Koch et al., 2012). But regarding ASPs, no applications regarding nurse support are identified in literature, probably because nurses are overlooked as stakeholder in ASPs. An antibiotic information app for nurses was developed to provide nurses with task support (Wentzel & van Gemert-Pijnen, 2014). It is called the antibiotic information app, and it makes information easily accessible. Nurses can find everything they need during their work, the information is grouped by the following categories: information needed to perform the primary tasks, important information and warnings, general or background information, extra checks and safety information, and information for specialists and medical background. This is demonstrated in figure 2.

Figure 2

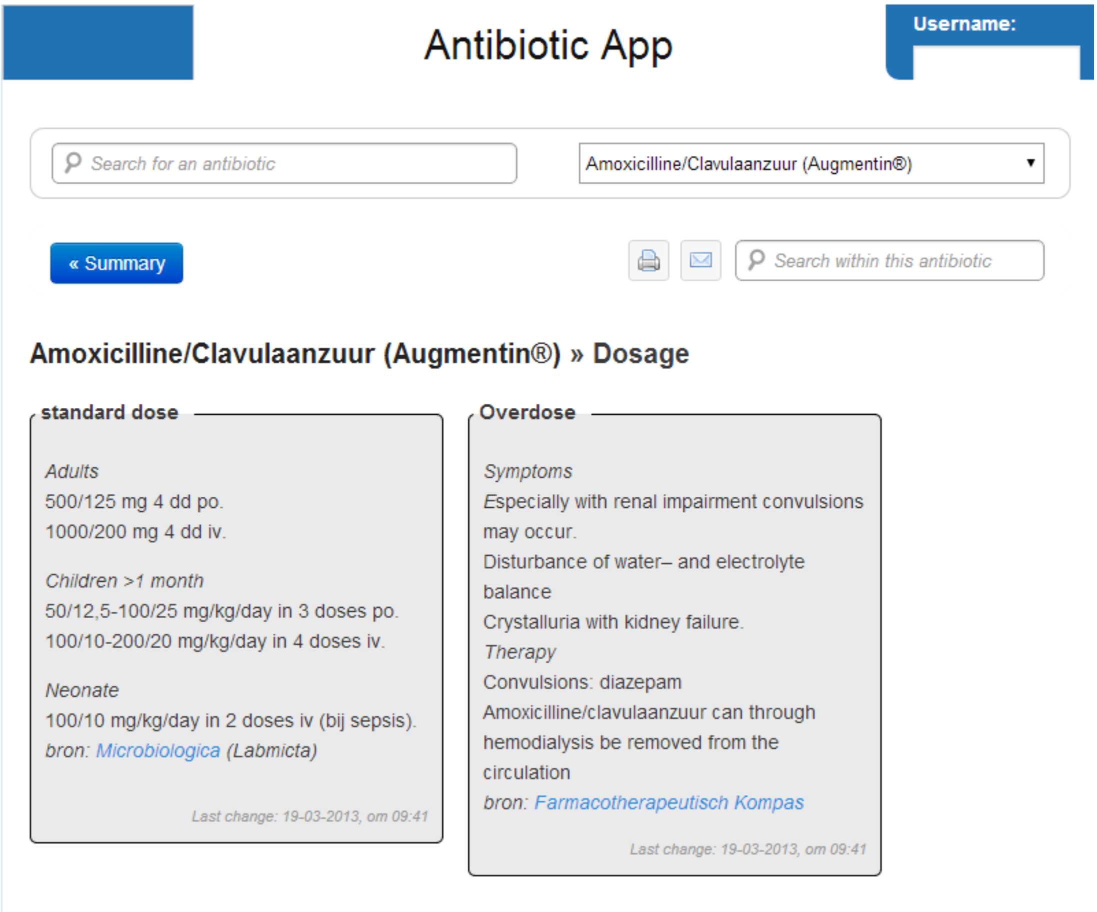
Antibiotic information app in categories



When nurses searched for an antibiotic, this was the first screen. This contained all information nurses might needed about the antibiotic. Nurses could click on every box to open a new screen with detailed information about the topic on the box. When nurses continued their search by clicking on dosage for example, they could find everything about the dosage for that specific medicine, including information when giving an overdose to a patient (this was shown in figure 3). This illustrates the principle of reduction, all information is reduced into small boxes of information. This simplified the search for information. Nurses may be better equipped to perform antibiotic tasks by providing easily accessible information, and are better able to recognize suboptimal antibiotic use (Wentzel et al., 2014).

Figure 3

Antibiotic App, specific dosage information



The application was developed in co-creation with nurses, who participated in the development and commented on various aspects of the app (from early concepts to working prototypes) (Wentzel et al, 2014). Nurses are the first to notice changes in a patients' status and have many other tasks to, which explains that the cognitive workload of nurses is very high. Nurses receive a lot of information from many different devices, including a lot of information which is important with regards to Antibiotic Stewardship. Integrated information could improve situational awareness of the patient, decrease errors and improve safety for the patients. An antibiotic app with organized and easily accessible information could be a solution, this app works as an integrated information system. In this research we evaluate if the Antibiotic App (Wentzel et al., (2014) is effective and if it supports nurses with regard to time to find correct information and satisfaction about the app. The following research questions lead this research:

- Does the antibiotic app support nurses regarding Antibiotic Stewardship?
- Are nurses faster with finding information than in the current situation?
- Are nurses better to find correct information?
- Are nurses experiencing less problems to find information?
- Are nurses more satisfied compared to the old situation?
- Are nurses more able to contribute to Antibiotic Stewardship?

This research intends to answer these questions. The expectation is that the participatory development process has resulted in positive effects for the use of the antibiotic app, regarding the amount of time to find information and the correctness of information. The expectation is that the effectiveness of the app is evaluated positively because of the participatory development and that it will be easier for nurses to find information with than without the antibiotic app.

Methods

The research was conducted by Wentzel & van Gemert-Pijnen (2014). There were nine scenarios created, together with a pharmacist and clinical microbiologist. This co-operation increased the validity of the scenarios. The scenarios presented situations that could arise during the work of nurses, and contained an information need about antibiotics. These cases contained the most critical moments in antimicrobial use, where mistakes were most likely and better information would have prevented mistakes. One of the scenarios was showed, translated from Dutch: “A COPD patient, gets Tobramycine, 1 time daily 240mg intravenous. The patient weighs 150kg. You are wondering whether this dose is adequate for this patient. Seek out.”. The answers were checked to see whether nurses found the correct solution or not (for this scenario: dosage is not adequate, too low) by means of a coding system (this coding system could be seen in table 1), time needed to find an answer (in seconds), how many problems nurses experienced while searching for the answer coded and counted according to a coding system for problems (Appendix A), and how many resources they needed while searching for the answer.

All nurses were asked to solve three scenarios. Sixteen nurses participated in the baseline measurements test (N=16), and thirty-three participated in the post-measurements (N=49 in total). The post-measurement consisted of two conditions, an experimental group and a control group (post-measurement with the app (N=16) and post-measurement without the app (N=17). The participants were divided randomly over the post-measurements and the participants differed in gender, age and work experience but they all worked in Medisch Spectrum Twente, a hospital in Enschede.

Scenario-based tests

During the baseline measurement, nurses had to solve the scenarios relying on their usual information sources and all nurses had no experience with the antibiotic information app. During post-measurement, all nurses have had access to the antibiotic information app for eight months. One group has solved the scenarios without the use of the antibiotic information app (thus according to the old situation, without the app) and the other group was allowed to solve the scenarios with use of the app. All participants received three scenarios and where asked to give a solution ("what would you do or what needs to be done?"). The scenarios were randomly divided. Nurses were asked to perform their information-search activities while talking out loud, like ask a colleague, seek information on the computer, etc. This activity was recorded on audiotape. The audio files were analyzed to determine a) whether the scenario was resolved correctly b) how many information source(s) were used c) whether any problems arose during the search; and d) how much time was needed to resolve the scenario. The transcripts of the interviews were coded according to a coding system for problems (which could be found in Appendix A). This system was checked by a second author to ensure the validity and reliability and was used to code the problems which arose during the search of the respondents. During this process, the system has been adjusted a couple of times because respondents made different statements than expected on forehand. The coding system consisted of 4 categories: problems, effectiveness, efficiency, and satisfaction. Problems was considered as the most important category, and this consisted of search strategy, understanding, structure, quality of information, completeness of resources and clearness. A problem was a negative experience with a system/search, a negative attitude towards a system/search method and difficulty in accessing, using or interpreting information. Problems consisted of more than one category, so this resulted in the fact that the amount of categories was higher than the amount of problems. Many respondents mentioned problems about the resources after they solved the scenarios but only the problems mentioned while solving a scenario were included in the first place since this was their true experience at that moment. The problems mentioned after solving the scenarios were taken into account too. If nurses mentioned the same problem more than once, this was counted as one problem. The amount of problems was counted for every respondent for every scenario and divided by three to receive the mean amount of problems for every respondent since all respondents solved three scenarios. All calculations were done with this mean score and the true score. The scenarios could be found in Appendix B. Whether the app was supportive regarding Antibiotic Stewardship was related to the correct solutions, since more correct solutions contributed to more correct use of antibiotics.

Correctness of the scenarios

The solutions for the scenarios were divided into six options, as can be seen in table 1. These codes could be further divided into three categories, with the labels positive, neutral and negative. The division was based on the fact whether the information resources were supportive or not.

Table 1

Solutions divided into codes and labels

Code	**Meaning**	**Label**
1	Wrong information and a wrong conclusion or no conclusion	Negative
2	A failed search for information and a wrong conclusion or no conclusion	Negative
3	(directly) asked for extern help	Neutral
4	Wrong information but a correct solution	Neutral
5	Correct information but a wrong conclusion	Positive
6	Correct information and a correct conclusion	Positive

A combination of code 1 and code 2 consisted of failed search, failed solutions and wrong actions, which meant the information resources were not supportive. Code 1 and 2 together were labeled as negative. Code 3 was not a wrong solution, but if the information was presented, it would have been better to find this information before asking for help. According to code 4, nurses were not always searching in the right place, but did found the correct solution, which almost always meant that they had to turn in someone else. So in both situations, the information resources were not supportive but it is not clear whether this is due to the nurses or the source itself. Code 3 and 4 together were labeled as neutral. Code 5 was the right information, but the nurse interpreted the information incorrectly. They searched were they had to, but the information was not complete/well matched so nurses made a wrong conclusion. Code 6 stated that the information was good and the conclusion was correct. Code 5 and code 6 were labeled as positive, since the information resources were available and supportive. This division was checked in the results section to make sure that this was the correct way to divide the codes.

Independent variables

There were three independent variables: the baseline measurement, the post-measurement without the app and the post-measurement with the app. The participants were randomly divided into these conditions. Firstly the baseline measurement, where respondents had no knowledge about the app. After this baseline measurement, the app was introduced to all nurses at specific units, so everyone could work with the app and experience the app. After 8 months, the post-measurements was done. This measurement was divided in 2 categories, a condition where participants were not allowed to use the app (post-measurement without the app) and a condition where participants were allowed to use the app (post-measurement with the app).

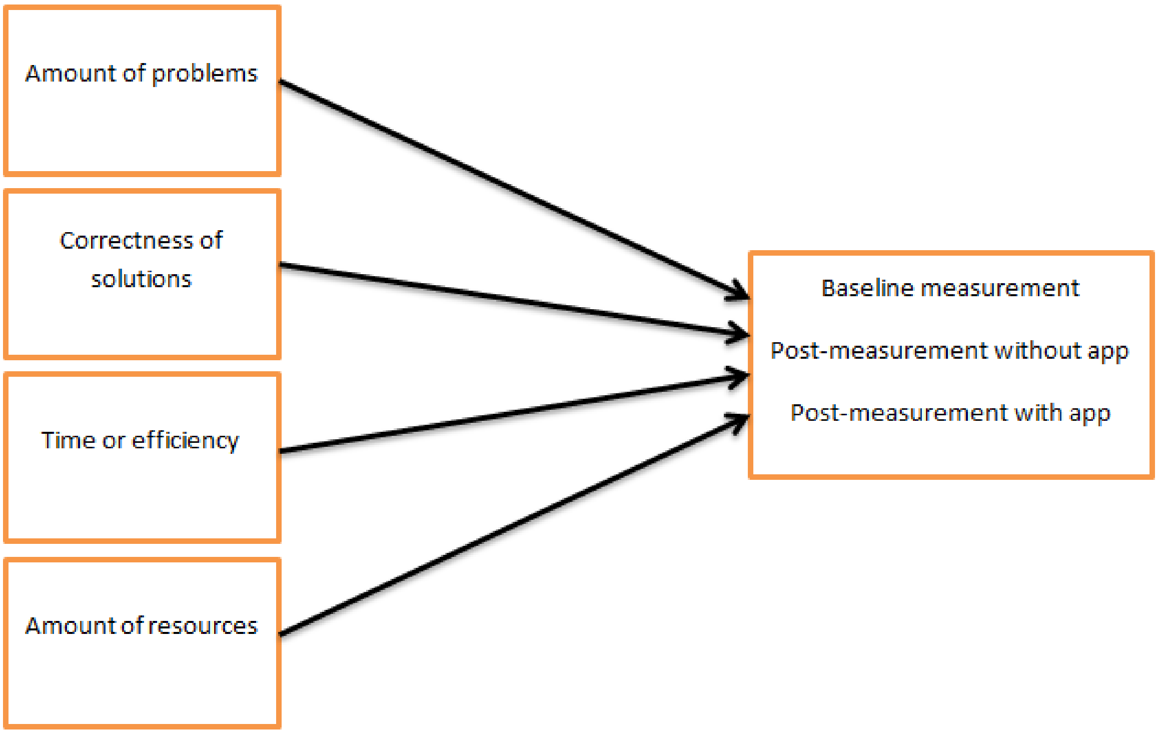
Dependent variables

There were four dependent variables: the amount of problems nurses experienced while solving the scenarios, the correctness of the solutions, the differences in time of efficiency and the amount of resources nurses used while solving the scenarios. For every condition, there were formed expectations about the results. Firstly, it was expected that nurses did experience less problems when they were allowed to use the app than when they were not allowed to use the app or during the baseline measurement. Secondly, the correctness of the solutions was checked and coded to see whether the information resource was more or less supportive to find the correct information. It was expected that information resources were more supportive during the post-measurement with the app than during the other conditions. Thirdly, the differences in time or efficiency. It was expected that nurses needed less time to solve a scenario when they were allowed to use the app than when they were not allowed to use the app. Finally, the amount of resources nurses used while solving the scenario. It was expected that nurses needed less resources when they were allowed to use the app (since the app intended to be a supportive information resource) than when they were not allowed to use the app.

The dependent variables were individually compared with the three conditions (independent variables), to see whether there were any differences between the conditions regarding problems, correctness, time or resources (this could be seen in figure 4). The mean score of the variables amount of problems, time and resources was calculated and included during the analyzes, as well as the true score. The correctness was divided into three labels, and included during the analyzes too. The mean scores were calculated because every respondent needed to solve three scenarios, and the mean score provided one score instead of three scores for every respondent. The true scores were taken into account to, since it could be that there were found insignificant effects due to the mean score. So to be sure that this would not happen, both the true scores and the mean scores were taken into account.

Figure 4

Model of dependent and independent variables



Statistical analyses

All analyses were done with a significance level of 95% (Cronbach's alpha=0,05). The normality of data was checked for all variables, as well as there was checked whether the groups were equally divided based on gender, age, internet use and work experience as a nurse and work experience at the current unit. This was done with one-way ANOVA analyzes. All tests were done one-tailed since the dependent variables were compared to the independent variables only, not vice versa nor were the dependent variables compared to each other.

The mean scores for problems, time and resources were calculated and used during the analyses as well as the original scores. The variable correctness was divided into labels (this could be seen in table 1). The dependent variables (amount of problems, correctness, time and resources) were individually compared to the independent variables (the three conditions). This was done by means of independent-sampled T Tests, to find out whether the differences between the conditions were significant. The amount of problems as well as the solutions (whether the scenarios were solved correctly or not) were coded by two coders. The agreement between two raters was calculated with Cohen's kappa. An overview of all variables and outcome measures was shown in table 2.

Table 2

Dependent variables and outcome measures

Variable	**Outcome measures***	**Data source**
Time	Number of seconds needed to complete scenario	Observation
Problems while solving	Number of experienced problems while solving scenario	Verbalization
Problems in total	Number of experienced problems in total	Verbalization
Used resources	Number of used resources to complete scenario	Verbalization
Correct solution	Scenario correctly or incorrectly solved	Verbalization

* Both expressed in number of scenarios during which problems were faced as well as in number of respondents encountered the problem. Repeated problems were only counted once.

Results

The scenario-based tests were completed by 50 nurses (N=50), 82% (N=41) were women and 16% (N=8) were men. The 2% was explained by missing values and this respondent (N=1) was excluded (Appendix C, 6). A one-way ANOVA analysis showed that the three groups did not differ significantly based on gender (p=0,884), age (p=0,470), internet use (p=0,375), work experience as a nurse (p=0,692) and work experience at the current unit (p=0,579) (Appendix C, 6). The mean age of the participants was 32,02 years. The average amount of years nurses worked at the current unit was 5,65 years, and the average amount they worked as a nurse was 9,14 years. The mean score for their internet use (at work as well as private) was 2,52 hours. 16 respondents completed the baseline measurements (condition 1), 17 respondents completed the post measurements without the app (condition 2), and 16 respondents completed the post measurements with the app (condition 3). The division of these variables in every condition could be seen in table 3 (this could be seen in Appendix C, 1, 2, 3 and 6 as well). Regarding gender, man was coded as 1, woman was coded as 2, so a mean score of 1.5 meant the distribution of men and women was equal.

Table 3

Distribution of independent variables in three conditions in mean scores (N=49)

	Baseline measurement		Post-measurement without app		Post-measurement with app	
	N	Mean	N	Mean	N	Mean

Gender	16	1,81	17	1,82	16	1,87
Age	16	32,13	17	29,82	16	34,25
Internet use	16	2,56	17	2,97	16	2,00
Work experience as a nurse	16	8,84	17	7,88	16	10,78
Work experience current unit	16	5,28	17	4,94	16	6,78

Inter-rater reliability for the problems coding system

Two coders scored the baseline measurement and the post-measurements with the coding system designed to score problems during the solving part, to see what the inter-rater reliability was. For the baseline measurement, Cohen's kappa was found to be 0,662. For the post-measurements, Cohen's kappa was 0,701. Both kappa's showed that there was a substantial agreement between the two raters.

Inter-rater reliability for solutions

The correctness for 51 scenarios was coded by two raters and the remaining 93 were coded by one rater. An inter-rater reliability was calculated. Cohen's kappa was 0,727, which showed that there was notable agreement between the two raters.

Differences between scenarios

A one-way ANOVA analysis showed that there were significant differences according to correctness for each scenario (p=0,001), so whether the solution was found or not did depend on the scenario (Appendix C, 12). This meant that it could be that the app was supportive in some scenarios, but was not supportive in other scenarios. All information resources (the app included) were more supportive for scenarios 1, 2, 3 and 5 than for other scenarios (mean score >2,5) since nurses found more correct solutions in these scenarios (Appendix C, 13). But since the scenarios were randomly divided among the participants, this could not explain why information resources used during the baseline measurement seemed to be slightly more supportive.

Correct solutions for division into labels

Not all scenarios and solutions could be taken into account since some data was lost and therefore the calculations were done with 144 scenarios. Code 5 and 6 were equally divided for all conditions, with no significant effect (p=0,822) (Appendix C, 7). This showed that it was a good decision to combine these codes into one category. The codes for the solutions were divided into three categories, negative, neutral and positive (this could be seen in table 1). The labels were numbered for the analyses. 1 meant a negative solution, 2 was a neutral solution and 3 was a positive solution. There was a significant effect (p=0.003) when the baseline measurement and the post-measurement with the app were compared. There were no significant effects when the baseline measurement was compared with the post-measurement without the app (p=0,102) and when the post-measurements were compared with each other (p=0,174).

Based only on mean scores, it seemed that respondents found less correct solutions during the post-measurement with the app (mean score was 2,28) than during the baseline measurement (mean score was 2,30), this was a significant effect. This could be seen in table 4 (as well as in Appendix C, 8, 9 and 10). So nurses found slightly more positive solutions during the baseline measurement than during the post-measurements which suggested that information resources were slightly more supportive to find correct information during the baseline measurement.

Table 4

Solutions divided into labels in mean scores (N=49)

	Baseline measurement		Post-measurement without app		Post-measurement with app	
	N	Mean	N	Mean	N	Mean
Correct solution	16	2,30	17	2,43	16	2,28

Correct solutions without division into labels

The solutions were compared without the division into 3 labels too. There was a significant effect when the baseline measurement was compared to the post-measurement with the app (p=0,023). The mean score for the post-measurement with the app was 4,24, and the mean score for the baseline measurement was 4,06. The codes and their meaning could be found in table 1. The other comparisons were not significant (p>0,250) (this could be seen in Appendix C, 32, 33 and 34). So nurses found more correct or positive solutions during the post-measurement with the app than during the baseline measurement. According to the percentages for every code in every condition, nurses found more correct conclusions with correct information (code 6) during the post-measurement without the app (18,8%) and the post-measurement with the app (16,0%) than during the baseline measurement (12,5%). Nurses asked for help (code 3) less frequently during the post-measurement with the app (only 4,9%), than during the post-measurement without the app (6,2%) or the baseline measurement (13,9%). All percentages were shown in table 5 (as well as in Appendix C, 11). So nurses found more correct solutions and asked les frequently for help during the post-measurement with the app than during the baseline measurement.

Table 5

Distribution of solutions in every condition (N=144)

	Baseline measurement		Post-measurement without app		Post-measurement with app	
	N	%	N	%	N	%
1: wrong information, wrong conclusion	3	2,1	5	3,5	5	3,5
2: failed search, wrong/no conclusion	3	2,1	5	3,5	8	5,6
3: (directly) asked for extern help	20	13,9	9	6,2	7	4,9
4: wrong information, wrong solution	1	0,7	0	0,0	0	0,0
5: correct information, wrong solution	2	1,4	5	3,5	3	2,1
6: correct information, correct solution	18	12,5	27	18,8	23	16,0

Correctly solved scenarios

The effects only for the correctly solved scenarios were compared too. Only the solutions with code 6 (correct information and correct solution) were taken into account. There were no significant effects but it seemed to be that the correct solutions could be found quicker during the condition with the app (121,70 seconds) than during the post-measurement without the app (207,15 seconds) and during the baseline measurement (211,83 seconds) (Appendix C, 14). A Chi-square test showed that there were no significant differences for the conditions regarding the amount of correctly solved scenarios ($\chi2 = 0,408$). During the baseline measurement, 18 scenarios were correctly solved. During the post-measurement without the app, 27 scenarios were correctly solved and during the post-measurement with app, 23 scenarios were correctly solved (this could be seen in table 6). So during the post-measurement without app, it seemed that nurses solve more scenarios correctly, but this difference was not significant. It seemed that nurses needed less time to find the correct solution during the post-measurement with the app, but this difference was not significant either.

Table 6

Time needed to correctly solve a scenario (N=68)

	Baseline measurement		Post-measurement without app		Post-measurement with app	
	N	Mean	N	Mean	N	Mean
Time (seconds)	16	211,83	17	207,15	16	121,70
Correctly solved	18		27		23	

Problems mentioned while solving and in total

The problems while solving the scenarios were counted, as well as the total problems nurses mentioned during the total interview, to see if the amount of problems differed for the three conditions. The amount of problems while solving did not differ significantly per condition (p>0,489). According to mean scores, it seemed that nurses experienced less problems while solving during the post-measurement with the app than during the other conditions, but this was not significant (table 7, Appendix C, 36). So nurses did not experience significantly more or less problems with the app.

The total problems (problems mentioned during the total measurement, while solving and after solving the scenarios) did differ significantly (p=0,010). This could be seen in Appendix C, 15. There was a significant effect for the total problems when the baseline measurement was compared to the post-measurement without the app (p=0,042). Nurses mentioned less problems during the post-measurement without the app than during the baseline measurement (Appendix C, 16, 17 and 18). There was an almost significant effect between the baseline measurement and the post-measurement with the app (p=0,073) and there was no significant difference between the post-measurements (p=0,664). The mean amount of total problems was 9,73 during the baseline measurement and 5,47 during the post-measurement with the app. Because this difference was almost significant, it seemed as if nurses mentioned more problems during the baseline measurement. The mean amount of total problems during the post-measurement without the app was 6,53, this difference was significant compared to the baseline measurement. All data could be seen in table 7. So nurses mentioned significantly more problems during the baseline measurement than during the post-measurement without the app, and it seemed that nurses mentioned less problems during the post-measurement with the app too.

Table 7

Total problems mentioned for every condition, mean scores (N=49)

	Baseline measurement		Post-measurement without app		Post-measurement with app	
	N	Mean	N	Mean	N	Mean
Problems while solving	16	3,69	17	3,59	16	2,56
Total problems	16	9,73	17	6,53	16	5,47

Comments about the app and other resources

The total amount of comments about the app was compared to the total amount of comments about other resources. This could be seen in table 8. 56,40% of all comments about the app was positive (respondent 38: “The app is clear, and contains all information I need as a nurse”) , compared to 13,63% of all comments about other resources (respondent 38: “This book is very useful because it contains all information you need”). 6,98% of all comments about the app was neutral (respondent 30: “I cannot find the information, but to click for further search is easy”), compared to 7,58% of all comments about other resources (respondent 5: “I search in Google always”). 36,63% of all comments about the app was negative (respondent 20: “The app does not contain all antibiotics, it is not complete”), against 78,79% of the comments about other resources (respondent 22: “This is not clear for me, it is unstructured and very small”). The quotes were examples of things nurses said during the scenario-based tests and translated from Dutch. The comments about the original resources during the baseline measurement were shown in table 8, as well as the comments in percentages for the post-measurements.

Table 8

Total comments about the app (N=49)

	Baseline measurement	Post-measurement about other resources	Post-measurement about app

	N	%	N	%	N	%
Positive	23	15,43	18	13,63	97	56,40
Neutral	9	6,04	10	7,58	12	6,98
Negative	117	78,52	104	78.79	63	36,63

The amount of mentioned problems reflected the satisfaction about the situation. During the baseline measurement, nurses seemed to be dissatisfied about their current information resources. This dissatisfaction included a negative understanding, negative search strategies (no clue where they could find the needed information), or problems with the structure (small types, huge texts). Satisfaction about resources included structure (information was structured and therefore could be found more easily), search strategy (it was clear where they needed to search) or the quality of information was high. The fact that the app was incomplete because there were missing some antibiotics was a frequently mentioned problem about the app, even as the understanding of the app (difficult language for example). These examples were not exhaustive, but showed what (dis)satisfaction could include. During the post-measurements, nurses made more positive comments about the app, which showed that nurses were more satisfied than dissatisfied about the app. The comments about other resources were more negative than positive, which showed that their satisfaction did not changed since the baseline measurement.

Mean time needed to solve a scenario

The time respondents needed to solve a scenario was noted in seconds. Since every respondent needed to solve three scenarios, the total of seconds was counted and divided by three to get the mean time a respondent needed to solve a scenario. The mean score for the baseline measurement was 227,86 seconds, which seemed to be higher than the mean scores for the post-measurement without the app (204,96 seconds) and the post-measurement with the app (174,73 seconds). The mean scores were shown in table 9. A one-way ANOVA showed that there was no significant difference between the conditions (p=0,097) for the mean scores of time needed to solve the scenarios. Although there seemed to be a considerable difference based on the mean scores, independent-samples T-tests showed that there were no significant results (Appendix C, 20, 21, 22 and 23).

Table 9

Mean time and true time for every condition in seconds (N=49)

	Baseline measurement		Post-measurement without app		Post-measurement with app	
	N	Mean	N	Mean	N	Mean
Mean time	16	227,86	17	204,96	16	174,73
True time	16	229,00	17	202,96	16	160,33

True time needed to solve a scenario

When the calculations were done without the mean scores (with the true scores), a one-way ANOVA showed that there was a significant difference between the three conditions (p=0,006). The difference between the baseline measurement and the post-measurement with the app was significant (p=0,030), even as the difference between the baseline measurement and the post-measurement without the app (p=0,014). The difference between the two post-measurements was not significant (p=0,887) (this could be seen in Appendix C, 24, 25, 26 and 27). The scores summarized in table 8 suggested that nurses needed more time to solve the scenarios during the baseline measurement (229 seconds), less time to solve the scenarios during the post-measurement without the app (202,96 seconds) and the least time to solve the scenarios during the post-measurement with the app (160,33 seconds). So based on the true scores, nurses needed less time to solve a scenario during the post-measurements than during the baseline measurement. Also, it seemed as if nurses were faster during the post-measurement with the app than during the post-measurement without the app, but this difference was not significant.

Used resources in every condition

The total of resources used by one participant was divided by 3 to find the mean amount of used resources for every scenario. A one-way ANOVA showed that there were no significant effects for the conditions (p = 0,141) (Appendix C, 28). When the mean differences were compared, there were no significant effects found between the baseline measurement and the post-measurement without the app (p = 0,127), the post-measurements (p=1.00) and between the baseline measurement and the post-measurement with the app (p=0,183). According to the mean scores, it seemed to be that there were less used resources during the post-measurement with the app (1,56 used resources) than during the baseline measurement (1,96 used resources) but this was not a significant difference. The mean score for the condition without the app was 1,72 used resources (table 10), (this could be seen in Appendix C, 29, 30 and 31).

Table 10

Used resources for every condition, mean scores (N=49)

	Baseline measurement		Post-measurement without app		Post-measurement with app	
	N	Mean	N	Mean	N	Mean
Used resources	16	1,96	17	1,72	16	1,56

Conclusion

Solving scenarios

With regard to correct solutions, there were no differences between the post-measurement with the app and the post-measurement without the app. There was a significant effect between the baseline measurement and the condition with the app, but this showed that the information resources were slightly more supportive to a correct solution during the baseline measurement. This was against the expectation because the app was supposed to be helpful, but did not led to more correct solutions. When the correctness was not divided into categories, it was shown that nurses asked for external help more frequently during the baseline measurement and the post-measurement without the app, compared to the post-measurement with the app. This suggested that the app was more helpful to find information and led to a reduced ask for help, but nurses found more correct solutions during the baseline measurement. It seemed that nurses needed less time to find the correct solution during the post-measurement with the app, but this was not significant.

Experienced problems

While solving the scenarios, there were no significant differences for the experienced problems. When the total problems were compared (all problems mentioned while solving the scenario and afterwards), there was a significant effect. Nurses mentioned more problems during the baseline measurement than during both post-measurements. Nurses mentioned less problems about the structure of the app during the post-measurement with the app. An explanation could be that nurses experienced less problems during their job because of the app.

Satisfaction

Nurses made more positive than negative comments about the app. This showed that nurses were quite satisfied with the app. Nurses made more negative than positive comments about the other resources, which showed that nurses were quite dissatisfied about other resources. So it seemed to be that nurses were more satisfied with the app than with the other resources.

Time needed for solving scenarios

With regard to time needed to solve a scenario, there were significant effects. Nurses needed more time during the baseline measurement than during the post-measurement with the app. This was according to the expectation, it seemed to be that the app contributed to a quicker solution. There was a significant effect for the difference between the baseline measurement and the post-measurement without the app too. This was against the expectation and could be due to different factors, which were discussed in the discussion. So this showed that nurses needed more time to solve the scenarios during the baseline measurement than during the post-measurements with and without the app.

Used resources

There were no significant effects found for the resources used while solving the scenarios. According to the mean scores, it seemed to be that there were less used resources during the post-measurement without the app compared to the baseline measurement, and the least used resources during the condition with the app, but this difference was not significant. So nurses used about as many resources during all conditions.

Research questions

The question of this research was whether the antibiotic information app was supportive or not, regarding time, correct solutions, problems, resources, satisfaction and contribution to Antibiotic Stewardship. This research showed that nurses needed less time to find the information during the post-measurements compared to the baseline measurement, which showed an increasing efficiency over time, but it was not sure whether this was due to the app or to other explanations. More correct solutions could contribute to Antibiotic Stewardship, but this was not demonstrated since it was not clear whether nurses found more or less correct solutions with the app. Nurses asked less frequently for help with the app than during the other conditions. They seemed to be quicker to find a correct solution with the app, but this was not significant. Nurses did experience about as many problems in all conditions while solving the scenarios, but during the post-measurement with the app, nurses mentioned less problems in total compared to the other measurements. This could mean that nurses experienced less problems in their normal work because of the app. Nurses made more positive than negative comments about the app, and made more negative than positive comments about the other resources. This suggested that nurses were more satisfied with the app. There were no differences found in used resources, which meant that nurses needed about the same amount of resources during the baseline measurement and the post-measurements.

To answer the research question, it was ambiguous whether the app was supportive regarding the efficiency since nurses did not significantly found more correct solutions. The results regarding support and the amount of experienced problems were not significant but nurses seemed to be more satisfied with the app than with the other resources. Nurses needed less time during the post-measurements to solve the scenarios, but it was not clear whether this was due to the app or to other factors. Based on these results, the conclusion was that the app could be supportive, and nurses seemed to be more satisfied with the app. It was not clear whether the app supported nurses to find the solution in less time, nor whether the app contributed to Antibiotic Stewardship, which meant that further research was needed.

Discussion

The results of this research are inconclusive and should be interpreted with caution. There were less significant effects than was expected, for example for the correct solutions. Nurses found or did not found the correct solution about as often in all conditions. While solving the scenarios, nurses mentioned that some scenarios were not real, the scenarios included things nurses never would have to do during their job for example. It was hard to find a solution in all conditions because of this, with or without the app, also because respondents had no clue were to search. It could be that there was a different effect when nurses evaluated all scenarios as reel. Another explanation could be that the app was not more helpful to find a correct solution compared to the other resources. This could be due to the fact that the information of the app consisted of information from the other resources. Especially the problem of understanding the information was mentioned a couple of times, and perhaps this could also explain why there were no differences found for this variable. This could explain why there were no significant effect for the amount of used resources too. Also, it could be that the app did not provide clear information, or provided information that suggested that external help was needed. When this was the case, it is obvious that nurses needed more than one resource to find the correct answer, which was equal to the conditions without the app. Also, since it was an antibiotic app, there was no information about other medicines, which was necessary to find the correct solution sometimes. Another explanation could be that the original resources did provide the correct information as well as the antibiotic app, which also could explain why there was no significant effect found since the app consisted of all resources from the old situation.

There were no significant effects between the post-measurements regarding time. This could be due to a learning curve because there was a time period of 8 months between the two measurements. This could be caused by external factors too, for example that the hospital invested in courses for nurses or in materials which could make their search for information easier too during these months.

There were no paired samples during this research, so it was not possible to search for a learning curve, but external factors like these could explain why there were no significant differences. Another explanation could be that there were nurses who participated during the baseline measurement as well as during the post-measurement. Because they already knew what was expected, since they had participated once before, it could have helped them to find a quicker solution and thus explained why there was a significant effect for the post-measurement without the app too. This could have influenced the results for all dependent variables, but the chance that this would have a huge impact is small since there was a time period of 8 months between the two measurements.

Some other issues were important to consider too: firstly the influence of the changing staff of the hospital by resign or leave for example. There were nurses who started to work after the introduction of the app, and therefore never heard about the research or the app. Other nurses left after the introduction of the app, so it was hard to tell whether or not all participants had the same experience with the app. The scenario-based tests took place in a less controlled research setting. This connected more to daily practice, but was more difficult to measure. For example not all possible resources were available in the resource setting, sometimes the pager made noise during the interview or another person entered the room and caused an interruption. This was hard to take into account during the processing of the results.

Also almost all scores were computed into mean scores, which could have influenced the results. To prevent this, calculations were done with the mean scores and the true scores to see if there were any differences. When this were (almost) significant differences, the true score was taken since this was a more true reflection of reality.

During the scenarios, it became clear that nurses needed support regarding antibiotic use. They needed information and the current resources were not always conclusive. Information was hard to find but necessary to do their job. The app seemed to be a good solution, since it combined all available information into one source, but the results of this research were not clear. It seemed that technology supported search strategy and although this research was not conclusive about the results, nurses said that the app was more clear and more helpful than the other resources. This was confirmed by research of Zadvinskis et al. (2013), they suggested that effective health technology should be congruent with nursing expectations. Nurses made more positive than negative comments about the app, which showed that they were more satisfied about the app. This satisfaction led to the conclusion that health technology could be helpful and supportive. Most expectations of this research were not conclusive, which meant that the expectations were not confirmed nor denied.

Based on this research, it was not clear whether the app was supportive or not. This could have many different reasons, but the expectations formulated before remained the same. The app could be supportive for nurses during their normal tasks, since not all scenarios were realistic. A recommendation for further research would be to complete the app (since there were some antibiotics missing) and to use paired samples instead of independent samples. Also more reel scenarios could make a difference. The learning curve over time could be investigated by doing this and perhaps it would lead to more results.

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Appendices

Appendices

Appendix A: Coding system

In Dutch:

Problemen:

-zoekstrategie: problemen met identificeren van juiste bron, en benaderen(vinden) van die bron
-begrip: mis-match tussen taalgebruik van experts en verpleegkundigen, inadequaat vocabulaire bij zoeken
- structuur: problemen bij vinden van specifieke informatie binnen een bron/pagina door gebrek aan structuur
- irreëel scenario: voorgestelde situatie ligt te ver van realistische taken/werkzaamheden
- kwaliteit van informatie: incorrecte informatie
-compleetheid van bron(nen): informatie is niet aanwezig in bron, hoewel wel verondersteld, informatie is überhaupt niet in goedgekeurde bronnen beschikbaar
- duidelijkheid: de gevonden informatie is duidelijk en helder

Effectiviteit:

- succesvol: scenario is succesvol voltooid
- moeite: kost veel/weinig moeite om de juiste informatie te vinden

Efficiëntie:

- tijd: tijd nodig om het scenario te voltooien, zoeken duurt lang/kort

- acties: aantal acties nodig om het scenario te voltooien
Tevredenheid:
- design: aantal uitdrukkingen gerelateerd aan het design
- inhoud: aantal uitdrukkingen gerelateerd aan de inhoud
- functies: aantal uitdrukkingen gerelateerd aan de functies

In English:

Problems:
- search strategy: problems to identify the correct resource, and to approach (find) that resource
- understanding: mismatch between language of experts and nurses, inadequate vocabulary while searching
- structure: problems to find the specific information within a resource/page because of a lack of structure
- unrealistic scenario: proposed situation is too far from the realistic tasks/proceedings
- quality of information: incorrect information
- completeness of resource(s): the information is not presented in a resource, although this is assumed
- clearness: the information found was clear

Effectiveness:
-successful: scenario is successful fulfilled
- effort: it took a lot/less effort to find the correct information

Efficiency:
- time: time needed to complete the scenario, search took long or short
- actions: the amount of necessary actions to complete the scenario

Satisfaction:
- design: amount of expressions related towards the design
- content: amount of expressions related towards the content
- functions: amount of expressions related towards the functions

Appendix B: Scenarios and solutions (in Dutch)

1. Een COPD patiënt, krijgt Tobramycine, 1xdaags 240mg intraveneus. De patiënt weegt 150kg. Je vraagt je af of deze dosering wel adequaat is voor deze patiënt. Zoek op. *
Nee, dosering is niet adequaat, te laag. (idem bij Gentamycine)
2. Een vrouw, opgenomen met een pseudomonas infectie krijgt 4x400mg/d IV Ciproxin. Deze dosering lijkt aan de hoge kant. Je wilt de arts bellen om te controleren of de dosering wel klopt. Je zoek het eerst zelf na.
Deze dosering is hoger dan de standaarddosering.
3. Een patiënt krijgt voor een thuis opgelopen pneumonie 4 x daags 1200 mg Augmentin. Na 4 dagen iv is patiënt koortsvrij en geef tijdens toediening aan wel naar te huis willen. Hoeveel dagen moet Augmentin iv gegeven worden?* *Een patiënt krijgt voor een thuis opgelopen pneumonie 4 x daags 1200 mg Augmentin. Bereid de medicatie voor.
Standaarddosering / instructies, te hoog, maar over duur geen info→ apotheek/arts bellen
4. Tijdens de visite wil de arts bij een van de patiënten met een luchtweginfectie Ciproxin vervangen door Claritomycine omdat de patiënt allergisch reageert op de cipro. De patiënt krijgt echter ook 3xdaags haloperidol vanwege onrust. Deze nieuwe combinatie van medicatie is niet gebruikelijk op jullie afdeling, je vermoedt vanwege een mogelijke interactie. Zoek op of je gevoel

	klopt.
Interactie tussen claritromycine en haldol → dus bij arts neerleggen	
5.	Een patiënt krijgt Erytomycine, IV 3 x daags 250 mg voor activeren van maag-darmkanaal. In verband met andere medicatie die gegeven moet worden wil je de Erytomycine het liefst zo snel mogelijk geven (in laten lopen). Zoek na hoe snel dit middel gegeven kan worden.
	30 min (max 500mg per uur)
6.	Patiënt, heeft een pneumonie veroorzaakt door pneumococcen, krijgt benzylpenicilline in een continupomp. In verband met een maagbloeding krijgt de patiënt ook een continupomp van esomeprazol. De arts heeft Nexium, 8 mg p/uur voorgeschreven. Ga na of deze combinatie haalbaar is.
	Nee, nooit esomeprazol samen toedienen (maar bij penicilline wordt dit niet genoemd!)
7.	Een patiënt krijgt Acenocoumerol i.v.m. met atriumfibrilleren. Je ziet de INR toenemen en vermoedt dat dit komt door de antibiotica (cotrimoxazol 2 x daags 960 mg) die de patiënt ook krijgt. Controleer of dit zou kunnen kloppen.
	Acenocoumarol = vit k antagonist, dus inderdaad co-trim can werking versterken→overleg met arts
8.	Patiënt krijgt vanuit huis Theofyline 2x350 mg daags. Wegens een pneumonie is de patiënt opgenomen en krijgt daar 2xdaags 500 mg cipro voor. De patiënt begint te klagen over misselijkheid en een opgejaagd gevoel. Ga na of deze klachten aan de medicatie kunnen liggen.
	Inderdaad interactie → overleg arts
9.	Een patiënt met een pneumonie krijgt 4x1200mg Augmentin. In het rapport van de klinische chemie zie je dat de GFR <20. Controleer of deze dosis past bij de nierfunctie.
	Te hoog.

*in de nameting is het scenario aangepast omdat het moeilijk/onmogelijk was de informatie te vinden of omdat het scenario echt niet gepast is.: dus alleen dit scenario in de nameting vergelijken.

Appendix C: tables of statistical analyses

1. Descriptives baseline measurement

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age	49	20	55	32,02	10,213
Years_Unit	49	,5	23,0	5,653	5,2581
Years_Nurse	49	,0	38,0	9,143	9,6712
Gender	49	1	2	1,84	,373
HoursInternet_work_and_private	49	,5	10,0	2,520	1,9737
Valid N (listwise)	49				

2: Descriptives post-measurement without the app

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age	16	21	54	32,13	11,442
Years_Unit	16	,5	23,0	5,281	5,7358
Years_Nurse	16	,0	34,0	8,844	10,3356
Gender	16	1	2	1,81	,403
HoursInternet_work_and_private	16	,5	10,0	2,563	2,4144
Valid N (listwise)	16				

3. Descriptives post-measurement with the app

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age	16	21	51	34,25	10,090
Years_Unit	16	,5	20,0	6,781	5,7763
Years_Nurse	16	,5	30,0	10,781	9,5951
Gender	16	1	2	1,87	,342
HoursInternet_work_and_private	16	,5	5,0	2,000	1,1106
Valid N (listwise)	16				

4. One-way ANOVA analysis for group differences

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Age	Between Groups	161,759	2	80,880	,768	,470
	Within Groups	4845,221	46	105,331		
	Total	5006,980	48			
Gender	Between Groups	,036	2	,018	,124	,884
	Within Groups	6,658	46	,145		
	Total	6,694	48			
Years_Unit	Between Groups	31,192	2	15,596	,554	,579
	Within Groups	1295,910	46	28,172		
	Total	1327,102	48			
Years_Nurse	Between Groups	71,392	2	35,696	,372	,692
	Within Groups	4418,108	46	96,046		
	Total	4489,500	48			

HoursInternet_work_and_private	Between Groups	7,807	2	3,903	1,002	,375
	Within Groups	179,173	46	3,895		
	Total	186,980	48			

5. Gender division

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	8	16,0	16,3	16,3
	female	41	82,0	83,7	100,0
	Total	49	98,0	100,0	
Missing	System	1	2,0		
Total		50	100,0		

6. Respondents in every condition

Condition

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Baseline measurement	16	32,0	32,7	32,7
	Post-measurement without App	17	34,0	34,7	67,3
	Post-measurement with App	16	32,0	32,7	100,0
	Total	49	98,0	100,0	
Missing	System	1	2,0		
Total		50	100,0		

7. No significance division of code 5 and code 6 at all conditions

ANOVA

Correctness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,045	2	,023	,196	,822
Within Groups	8,673	75	,116		
Total	8,718	77			

8. Correctness post-measurement without app and post-measurement with app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Correctness_3_categories	post without app	51	2,4314	,80635	,11291
	post with app	46	2,2826	,88602	,13064

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Correctness_3_categories	Equal variances assumed	1,876	,174	,866	95	,389	,14876	,17183	-,19235	,48988
	Equal variances not assumed			,862	91,427	,391	,14876	,17267	-,19420	,49173

9. Correctness baseline measurement and post-measurement without the app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Correctness_3_categories	baseline measurement	47	2,2979	,68888	,10048
	post without app	51	2,4314	,80635	,11291

Independent Samples Test

	Levene's Test for Equality of Variances	t-test for Equality of Means

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Correctness_3_categories	Equal variances assumed	2,727	,102	-,878	96	,382	-,13350	,15213	-,43547	,16847
	Equal variances not assumed			-,883	95,470	,379	-,13350	,15115	-,43355	,16655

10. Correctness baseline measurement and post-measurement with app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Correctness_3_categories	baseline measurement	47	2,2979	,68888	,10048
	post with app	46	2,2826	,88602	,13064

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Correctness_3_categories	Equal variances assumed	9,520	,003	,093	91	,926	,01526	,16437	-,31124	,34177
	Equal variances not assumed			,093	84,921	,926	,01526	,16481	-,31243	,34296

11. Correctness and condition in percentages

Condition * Correctness Crosstabulation

			Correctness						Total
			1	2	3	4	5	6	
Condition	baseline measurement	Count	3	3	20	1	2	18	47
		% of Total	2,1%	2,1%	13,9%	0,7%	1,4%	12,5%	32,6%
	post without app	Count	5	5	9	0	5	27	51
		% of Total	3,5%	3,5%	6,2%	0,0%	3,5%	18,8%	35,4%
	post with app	Count	5	8	7	0	3	23	46
		% of Total	3,5%	5,6%	4,9%	0,0%	2,1%	16,0%	31,9%
Total		Count	13	16	36	1	10	68	144
		% of Total	9,0%	11,1%	25,0%	0,7%	6,9%	47,2%	100,0%

12. Significant difference according to correctness for every scenario

ANOVA

Correctness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	88,389	8	11,049	3,728	,001
Within Groups	400,049	135	2,963		
Total	488,438	143			

13. Correctness for every scenario

Report

Correctness_3_categories

Scenario	Mean	N	Std. Deviation
1	2,6471	17	,70189
2	2,8125	16	,54391
3	2,5333	15	,83381
4	2,1765	17	,72761
5	2,5333	15	,83381
6	1,9375	16	,77190
7	2,1765	17	,63593
8	2,3333	18	,84017

9	1,8462	13	,89872
Total	2,3403	144	,79477

14. Time needed to solve scenario correctly with correct information(code 6)

Report

Time_scenario

Condition	Mean	N	Std. Deviation
baseline measurement	211,8333	18	121,13787
post without app	207,1481	27	88,31312
post with app	121,6957	23	66,30195
Total	179,4853	68	99,64586

15. Significant difference for total problems

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Problems_while_solving	Between Groups	12,507	2	6,254	,868	,427
	Within Groups	331,493	46	7,206		
	Total	344,000	48			
Problems_total	Between Groups	148,970	2	74,485	5,114	,010
	Within Groups	640,902	44	14,566		
	Total	789,872	46			

16. Total problems baseline measurement and post-measurement without app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Problems_total	1,00	15	9,7333	5,10555	1,31825
	2,00	17	6,5294	3,08459	,74812

Independent Samples Test

	Levene's Test for Equality of Variances	t-test for Equality of Means

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Problems_total	Equal variances assumed	4,509	,042	2,178	30	,037	3,20392	1,47082	,20010	6,20774
	Equal variances not assumed			2,114	22,434	,046	3,20392	1,51574	,06399	6,34385

17. Total problems baseline measurement and post-measurement with app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Problems_total	1,00	15	9,7333	5,10555	1,31825
	3,00	15	5,4667	2,97289	,76760

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Problems_total	Equal variances assumed	3,460	,073	2,797	28	,009	4,26667	1,52545	1,14193	7,39140
	Equal variances not assumed			2,797	22,515	,010	4,26667	1,52545	1,10727	7,42606

18. Total problems post-measurement with and post-measurement without app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Problems_total	2,00	17	6,5294	3,08459	,74812
	3,00	15	5,4667	2,97289	,76760

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Problems_total	Equal variances assumed	,192	,664	,989	30	,331	1,06275	1,07442	-1,13151	3,25700
	Equal variances not assumed			,991	29,745	,329	1,06275	1,07187	-1,12708	3,25257

19. Mean score for time in every condition

Report

Mean_Time

Condition	Mean	N	Std. Deviation
1,00	227,8750	16	62,74400
2,00	204,9600	17	66,00862
3,00	174,7281	16	75,15600
Total	202,5708	49	70,15430

20. Mean time for baseline measurement and post-measurement without app

Independent Samples Test

	Levene's Test for Equality of Variances	t-test for Equality of Means

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Mean_Time	Equal variances assumed	,000	,996	1,021	31	,315	22,91500	22,44879	-22,86960	68,69960
	Equal variances not assumed			1,022	30,996	,315	22,91500	22,41323	-22,79734	68,62734

21. Mean time for baseline measurement and post-measurement with app

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Mean_Time	Equal variances assumed	,792	,381	2,171	30	,038	53,14687	24,47605	3,16011	103,13364
	Equal variances not assumed			2,171	29,073	,038	53,14687	24,47605	3,09319	103,20056

22. Mean time post-measurement without and post-measurement with app

Independent Samples Test

	Levene's Test for Equality of Variances	t-test for Equality of Means

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Mean_Time	Equal variances assumed	,700	,409	1,230	31	,228	30,23188	24,58512	-19,90981	80,37356
	Equal variances not assumed			1,225	29,908	,230	30,23188	24,68458	-20,18729	80,65104

23. No differences for mean time in all conditions

ANOVA

Mean_Time

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22745,314	2	11372,657	2,450	,097
Within Groups	213492,696	46	4641,146		
Total	236238,010	48			

24. True time scores, differences between conditions

ANOVA

Time_scenario

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	111707,296	2	55853,648	5,249	,006
Within Groups	1500310,030	141	10640,497		
Total	1612017,326	143			

26. True time baseline measurement and post-measurement without app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Time_scenario	baseline measurement	47	229,0000	127,05665	18,53312
	post without app	51	202,9608	86,47195	12,10850

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time_scenario	Equal variances assumed	6,234	,014	1,194	96	,235	26,03922	21,80550	-17,24437	69,32280
	Equal variances not assumed			1,176	80,207	,243	26,03922	22,13802	-18,01511	70,09354

26. True time baseline measurement and post-measurement with app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Time_scenario	baseline measurement	47	229,0000	127,05665	18,53312
	post with app	46	160,3261	92,35729	13,61734

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time_scenario	Equal variances assumed	4,834	,030	2,976	91	,004	68,67391	23,07528	22,83770	114,51012
	Equal variances not assumed			2,986	84,037	,004	68,67391	22,99801	22,94015	114,40768

27. True time for post-measurement without and post-measurement with app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Time_scenario	post without app	51	202,9608	86,47195	12,10850
	post with app	46	160,3261	92,35729	13,61734

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time_scenario	Equal variances assumed	,020	,887	2,348	95	,021	42,63470	18,15987	6,58280	78,68660
	Equal variances not assumed			2,340	92,339	,021	42,63470	18,22217	6,44566	78,82374

28. ANOVA for resources, no significant differences between conditions

ANOVA

Resources

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,282	2	,641	2,045	,141
Within Groups	14,421	46	,314		
Total	15,703	48			

29. Resources for baseline measurement and post-measurement without app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Resources	Baseline measurement	16	1,9594	,76818	,19204

	Post-measurement without App	17	1,7247	,37773	,09161

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Resources	Equal variances assumed	2,455	,127	1,124	31	,270	,23467	,20875	-,19108	,66041
	Equal variances not assumed			1,103	21,557	,282	,23467	,21278	-,20713	,67647

30. Resources for baseline measurement and post-measurement with app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Resources	Baseline measurement	16	1,9594	,76818	,19204
	Post-measurement with App	16	1,5612	,46810	,11703

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Resources	Equal variances assumed	1,857	,183	1,770	30	,087	,39813	,22489	-,06116	,85741

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
	Equal variances not assumed			1,770	24,790	,089	,39813	,22489	-,06525	,86150

31. Resources for post-measurement with and without app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Resources	Post-measurement without App	17	1,7247	,37773	,09161
	Post-measurement with App	16	1,5612	,46810	,11703

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Resources	Equal variances assumed	,000	1,000	1,107	31	,277	,16346	,14764	-,13766	,46457
	Equal variances not assumed			1,100	28,858	,280	,16346	,14862	-,14057	,46748

32. Significant effect for correction baseline measurement and post-measurement with app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Correction	baseline measurement	47	4,0638	1,69916	,24785
	post with app	46	4,2391	1,97973	,29189

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Correctness	Equal variances assumed	5,310	,023	-,459	91	,648	-,17530	,38229	-,93468	,58408
	Equal variances not assumed			-,458	88,352	,648	-,17530	,38292	-,93624	,58564

33. Significant effects for correctness between post-measurements

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Correction	post without app	51	4,4902	1,86947	,26178
	post with app	46	4,2391	1,97973	,29189

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Correctness	Equal variances assumed	1,338	,250	,642	95	,522	,25107	,39092	-,52500	1,02713
	Equal variances not assumed			,640	92,590	,524	,25107	,39208	-,52758	1,02971

34. No significant effects for correctness regarding baseline measurement and post-measurement without app

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Correction	baseline measurement	47	4,0638	1,69916	,24785
	post without app	51	4,4902	1,86947	,26178

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Correctness	Equal variances assumed	,950	,332	-1,178	96	,242	-,42637	,36191	-1,14476	,29202
	Equal variances not assumed			-1,183	95,984	,240	-,42637	,36049	-1,14194	,28921

35. Chi square test for conditions and correct solution (code 6)

Condition

	Observed N	Expected N	Residual
baseline measurement	18	22,7	-4,7
post without app	27	22,7	4,3
post with app	23	22,7	,3
Total	68		

Correction

	Observed N	Expected N	Residual
6	68	68,0	,0
Total	68[a]		

a. This variable is constant. Chi-Square Test cannot be performed.

Test Statistics

	Condition
Chi-Square	1,794[a]
df	2
Asymp. Sig.	,408

a. 0 cells (0,0%) have expected frequencies less than 5. The minimum expected cell frequency is 22,7.

36. Mean scores for problems while solving

Report

Problems_while_solving

Condition	Mean	N	Std. Deviation
1,00	3,6875	16	2,54869
2,00	3,5882	17	2,82973
3,00	2,5625	16	2,65754
Total	3,2857	49	2,67706