Developing an independently executable simulation training for ERCP

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ABSTRACT - Although simulators are widely recognized as being a valuable tool in ERCP training, the current use of simulation models in ERCP training program is still minimal due to the limited availability of instructors. This study aims to develop an independently executable training for the "ERCP Trainer", a mechanical simulation model, that effectively and efficiently provides training in the most essential aspect of ERCP; cannulation. Several means are developed in which the instructor's main tasks of providing instructions, feedback and assessment are fulfilled by technological aids. All means together, form the independently executable training program. The effectivity of the program was tested by comparing the cannulation skills of a subject group that executed the developed training program with a control group. The difference in measured skill were rather small (*5.83/10.00* score vs. *5.59/10.00* score of control group) and due to the low sample size of the subject group, the results are not significant. While the test results are inconclusive, the developed training shows a lot of potential due to the advantages of the incorporated serious gaming elements and the relatively easy implementable proposed solutions for the found points of improvement.

1 INTRODUCTION

1.1 Background

ERCP is one of the most technically demanding and risky procedures to perform by a gastroenterologist. The complication rate is approximately 9.8% [1], with post ERCP pancreatitis being the main culprit as it occurs in about 5.4% of the cases [1]). To safeguard the well-being of the patient, difficult and risky procedures such as ERCP should therefore only be carried out by sufficiently skilled performers. For acquiring the required skills, a great deal of training is needed. In most medical institutions training is provided by means of the master-apprentice method in which the trainee participates in the real clinical setting and the instructor, a qualified endoscopist, acts as a supervisor who can intervene in risky situations. This form of training, in which the trainee learns by trial and error, puts the patient's well-being at risk [2-5]. On top of that it also leads to longer OR times [6] and it suffers from limitations in terms of procedural frequency and variety because the type and amount of performed procedures fully depends on the incoming patients.

Opposed to the traditional master-apprentice teaching, simulation training offers a way of learning in a controlled environment which does not affect the patient's well-being, allowing the trainees to make mistakes. Simulators are not realistic and complete enough yet to fully obviate training in clinical practice, but especially in the first phase of training simulators can be valuable to learn the basic skills on without any risks or limitations in case-frequency and case-mix.

Although the use of simulators in training is recommended by societies and experts, simulator-based training is seldom implemented in the curriculum for ERCP training [7-9]. The reason for the non-use of course differs a bit per simulator type, but "a lack of time" can be seen as the main limiting factor for the incorporation of simulators into the training program. In contrast to master-apprentice training in which teaching takes place during their scheduled operations, teaching on a simulator takes place as separate activity that comes on top of their tight schedule. Finding sparse time in their full schedules appears to be very difficult, especially when it has to meet the schedule of the trainees as well. For this reason, the UMC Amsterdam only provides simulator training to their AIOS (physicians in training) once or twice a year. This problem, the lack of time, is also mentioned numerous times in literature, not only for ERCP teaching but also for other disciplines that have the availability of simulator models for training [10-12].

1.2 Problem definition.

The fact that the need for an expert instructor to be present during the training appears to be the problem instead of the actual capabilities of the simulator device, suggests that the solution for proper incorporation of simulators into the ERCP training curriculum might be; replacing the instructor by some means. To provide simulation training that is available to the trainee at any desired moment, the training needs to be independently executable by the trainee, without the need for the instructor to be present.

1.3 Study goal

The goal of this research study is to develop an independently executable training for the ERCP trainer, a mechanical simulator by Boškoski and Costamagna [13], that effectively and efficiently teaches beginners the most important ERCP skills (see chapter 8.1 of thesis for model specifications).

The training will focus on the absolute beginners, because the start of practical training, in which the trainees are highly unskilled and operate solely by means of trial and error, forms the greatest risk for the patient's health. Using a simulation model instead of the real patient for this first part of the ERCP training would be a beneficial measure to decrease the patient-risk, because only the more experienced (gained by simulation training) trainees will then participate during the real clinical practice.

2 IDENTIFYING THE TRAINING OBJECTIVES AND NEEDS

2.1 Training objectives

Considering that essentially every ERCP procedure starts with selective cannulation and that cannulation is, moreover, almost invariably used as the benchmarks for accrediting competence [14-18], the main objective of the training will be cannulation centered. The act of cannulation covers all the basic side-viewing endoscopy motor skills (e.g. controlling the side-viewing scope, hand-eye coordination from observing a display, scope positioning, precisely directing the catheter). Training on cannulation can therefore be considered as an adequate measure for developing the basic practical skills of ERCP. The training objective will therefore be to facilitate a training that improve selective cannulation skills.

Besides the main objective of facilitating independently executable training in cannulation, there are also some secondary objectives to account for. The favorable features of mechanical simulators are aimed to be preserved in the new mean(s), of which the most important ones are: relatively low cost, easy to use, easy to re-use, safe (no patient used) and no animal tissue used. The process of identifying the main training objective and the secondary objectives can be found in chapter 6 of the thesis.

2.2 Training Needs

The act of cannulation consists of various different elements and steps that need to be combined or conducted consecutively in order to perform cannulation properly. In an effective and efficient training program, each of these elements thus needs to be covered and therefore all the fundamental elements must be identified clearly when designing the training for the ERCP trainer. The core elements for performing cannulation will be the defined as the "training needs" of the to-be-developed training and are depicted below. The process of identifying the training needs can be found in chapter 7 of the thesis.

1. controlling the scope
2. route to the papilla
3. positioning in front of the papilla
   - ⇒ The papilla needs to be located on the lower left corner of the upper right quadrant of the display. The papilla should be faced en-face, while the long axis of the papilla is in line with the 12 o'clock position
4. guiding the catheter
   - ⇒ When the scope is positioned in front of the papilla as instructed, successful selective cannulation can be achieved by guiding the catheter towards the 11 o'clock direction for entering the common bile duct (CBD) and towards 2 o'clock for entering the pancreatic duct (PD) [19]
5. combining positioning and catheter advancement for cannulation.

2.3 The needs for independent practice

To facilitate a proper independently executable training, the traditional tasks of the teacher must be covered by some means. The tasks of the human training provider in current simulation training primarily consist of: 1) give instructions, 2) provide feedback to the trainee during and after the performance, 3) assessment of the performance and additionally also 4) documentation to observe learning curves. For this project, pre-defined multimedia is used for providing the instructions and for the feedback, assessment and documentation tasks, which require a form of intelligence, the technology is used. In order to keep the to-be-developed means simple but at the same time also effective and efficient, several aspects of education theory and serious games are used (see chapter 8.2 and 8.3 in the thesis for an elaborative study on these concepts).

3 DEVELOPED TRAINING MEANS

Independently executable training on every skill(set) that is described in the training needs shall be facilitated by several different training means. Skill acquisition will be established by instructions and exercises which incorporate feedback and assessment. The developed instructions and exercises (with feedback and assessment) are the actual products (means) of this research study. All the training means together will form a complete training from beginning to end on the cannulation.

3.1 Mean for training the route to the papilla

After deliberate consideration, it was decided to leave "practicing the route to the papilla" out of the training program and thereby repealing it as a training need. The reason for this is that for facilitating training in this skill, an additional model is needed because the esophagus, stomach and duodenum are not realistically presented in the ERCP trainer. Currently there are no appropriate models available which realistically represent the area of interest. Creating a realistic model would demand time and effort, while the necessity of training the route appeared to be subject of debate. Although suggested otherwise in literature [20], Both Dr. Boskoski and Dr. Koch state that the route is not considered as a skill that needs explicit training as it is a relatively easy task for which competency evolves almost automatically during the training of other skills. Their statements together with the fact that the route is just one of the needs and developing a mean for this will require a lot of time and effort, resulted in dismissing the route as a training need.

3.2 Mean for providing general instructions and getting familiar with the scope

The training will start with a general introduction that explains the basic principles of ERCP, the criteria for correct scope positioning and the guidelines for catheter advancement into a duct of interest. Also, the instructions for controlling the scope are provided in this introduction. The information is provided by means of a PowerPoint presentation. For the construction of this presentation the segmentation-, coherence-, redundancy-, multimedia-, and pre-training principles of learning theory are taken into account (see chapter 8.2.1.1 of thesis): the presentation needs to be studied already once before start of the training (is emailed to the trainees), videos are not combined with (long) written texts, extraneous elements are limited, information is provided segmented and there is the option to skip or fast-forward parts (slides) or request more information by means of pop-ups which accounts for different learning rates of the participants. The trainee may participate with the instructions on how to control the scope. By participating, the trainee gets acquainted with the duodenoscope. True control over these skills will be established in the upcoming exercises. The PowerPoint presentation can be found in Appendix A of the thesis.

3.3 Mean for practicing scope control and positioning (Exercise 1)

The guidelines on what the correct position in front of the papilla is for successful cannulation (rule-based behavior) are administered in the instruction providing mean, but developing the skill-based behavior for both controlling the scope and learning to correctly position the scope will be accounted for in a compatible exercise in form of a game. The goal of the exercise is to guide the scope, as quickly as possible, towards a position in which the three dots (red, blue, green) that are depicted on the papilla of the model, appear within their matching target areas on the display. The instructions for the game/exercise are provided by means of a PowerPoint slide that contains written text and explanatory images. The feedback, assessment and documentation are covered by means of the game. The game, developed in MATLAB, uses the real-time video images of the scope as input. Color recognition is used to detect the markers. Several strict criteria are implemented which detected objects must meet (e.g. size and form) in order to be acknowledged as a correct marker. An object that meets the criteria is encircled red, blue or green (color corresponds with the color of the detected object). To complete the exercises, the detected markers need to be at the correct location on the display (criteria for proper location are based on the requirements for proper positioning). When a marker is located in its depicted target area, the contour of target area will light up yellow (Figure 1A). When all markers are located in their target areas, the contour of the whole papilla will light up yellow and the exercise will stop (Figure 1B). Data as the name, date and required time to achieve the goal, will be saved. The working principles of the exercise are explained in more detail in chapter 9.3 of the thesis, and the MATLAB script for the developed game can be found in Appendix D of the thesis.

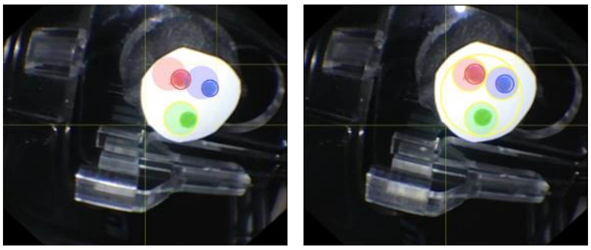


Figure 1A Screen short during exercise. Three dots detected, of which one dot is located in within the target area. **Figure 1B** Screen shot when exercise is successfully completed. All dots detected and located within the target area.

3.4 Mean for practicing catheter advancement. (Exercise 2)

Guidance of the catheter will be trained in the second exercise, that is also designed as a game. The goal of this exercise is to direct the catheter towards a requested position. The requested positions are in this case the red, blue or green marker dots on the papilla, similar the previous exercise. The dots need to be tapped consecutively in the order provided on the display, as quickly and accurate as possible. Touch sensors on the surfaces of the dots can by means of an Arduino Uno device be used as inputs for the second game that is also developed in MATLAB. During the game, a real-time graph is generated which envisions the touches over time (see Figure 4). The order can for instance be: *"red, blue, red, green, red, green, blue, red,* retract scope*, blue, green, red, green, blue, red, blue, green, red, …"* In-between sequences of colors, the scope must sometimes be retracted so that a proper position in front of the papilla to execute the tapping from must be established again. This way, the acts of positioning and catheter advancement are merged.

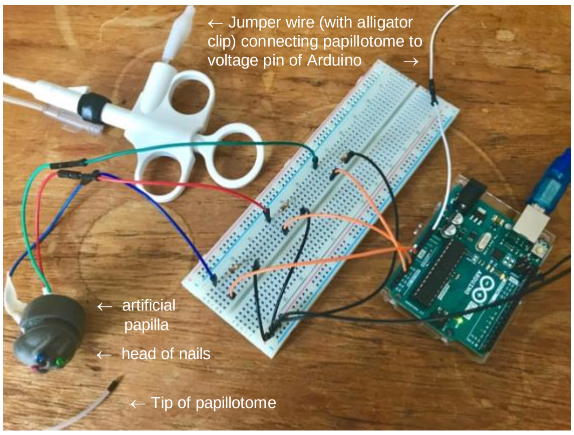


Figure 2 Picture of the developed circuit of exercise 2.

By means of this exercise, the participant learns to control the elevator knob that is needed for catheter advancement and he/she learns where the catheter must be directed to (11 o'clock for cannulation of the bile duct, 2 o'clock for cannulation of the pancreatic duct) for successful cannulation of each of the ducts. The instructions on how to control the elevator knob are provided by means of a short movie and written text on the PowerPoint presentation. The instructions on where to navigate the catheter to for which duct are already provided in the general instructional slides of the presentation and in the explanation of the first exercise. The working principles of the exercise are explained in more detail in chapter 9.4 of the thesis, and the MATLAB script for the developed game can be found in Appendix E of the thesis.

4 TESTING OF THE DEVELOPED MEANS

As positioning and proper catheter directing have been described as the crucial elements of successful selective cannulation (assuming that scope control will also develop during exercise 1 and possibly also exercise 2) and the developed training concept contains exercises that provide training on both aspects in the sequence in which the tasks must also be executed during real practice, executing the developed training should, in theory, result in improved cannulation skills and increased success rates [21]. To determine the effectiveness of the developed training, some tests must be done. The effectiveness of the developed training program will be tested by comparing the skills of a subject group (Group 1) that has executed the developed training, with a subject group (Group 2) that did not execute the training. Regardless of the true effectiveness of the constituted training, the fact that trainee get some form of experience with the duodenoscope will lead to improvement of their skills. Therefore, Group 1 needs to be compared with a subject group that receives the same amount of exposure to the duodenoscope and the ERCP trainer, but without being guided by a training program.

4.1 Method

Six trainees that are in their 4th of 5th year of the gastroenterology program in the Amsterdam UMC were selected for the experiment, as 4th and 5th year trainees do have some forward-viewing endoscopy experience, but no side-viewing endoscopy experience. Three trainees were randomly assigned to group 1 and the remaining three trainees were assigned to the control group 2. In fulfilment of the pre-training principle both groups received the same PowerPoint presentation that they needed to go through, two days prior to the experiment, which contained instructions for selective cannulation, on how to control the duodenoscope etc. (See Appendix A and first part of Appendix C of the thesis). The same presentation was also shown to the trainees at the beginning of their first exercise, only now they were instructed to participate with the directions on how to control the duodenoscope. During the exercise, they receive five minutes to go through the presentation, before their first exercise really starts.

The experiment consists of four exercises, of which the first three take place in two different rooms. During each exercise, only one trainee will be present in each room, together with a supervisor. The supervisor will not provide any instructions but is needed to assist with the catheter advancement (exercise 2 and 3) and to observe the proceedings for afterwards feedback. Catheter advancement can also be done without assistance, but to save time (time for conducting the experiment was limited), assistance was provided so that all time is spend on the task of interest and not on a side issue. Moreover, during real ERCP, an assistant helps with the catheter advancement trough the biopsy port. This task is therefore not part of the training needs. The trainees of group 1 do their first three exercises in room 1 in which the required elements for the developed training program are installed; the computer that runs the MATLAB script for the two games is connected to the duodenoscope tower, the adjusted papilla with the color markers is attached to the model (different papilla for exercise 1 and 2), and for the second exercise the Arduino set-up is attached. For group 1 the first exercise is equal to the first exercise of the developed training. During this exercise, the trainees have 8 minutes to complete the game (positioning the scope correctly in front of the papilla) as often as possible. After completion of every game, the scope must be retracted out of the model, to start over again. Prior to the game, the trainees have 5 minutes to go through the instructions on how to direct the scope. The instructions will finish with a slide that explains the exercise to the trainee. In the other room, trainees of group 2 receive the same prior instructions during exercise 1, but their last slide is different; their assignment is to play with the duodenoscope and model for 8 minutes. They are not allowed to use the catheter yet. They look at the normal monitor instead of the computer and a normal papilla without an opening (to avoid cannulation attempts) is attached to the model.

For the trainees of group 1, the second exercise is equal to the second exercise of the developed training. They have 5 minutes execute the exercise and cover as much of the provided sequence as possible. Group 2, again, is assigned to play with the scope and model for 5 minutes. The catheter can now be used by group 2, but cannulation of the papilla may not be attempted yet (papilla still has no opening). Exercise three is exactly the same for both groups; cannulation of the CBD (Common bile duct) may be attempted for 5 minutes and therefore a papilla with an opening ductal system attached to it, is fixed to model. The fourth exercise is also identical for both groups and takes places in the same room (room 2) for both groups. The trainees are asked to cannulate the CBD as often as possible within 5 minutes. The overview of all the whole training, including the exercises, can be found in Appendix C of the thesis. During exercise 4, an expert will assess the performance of each trainee (of both groups) based on some quantitative measurements and some subjective measurements that were retrieved from the OSATS form [22]:

Quantitative measurements:

I. Time needed to cannulate the CBD
II. Number of PD cannulations during each attempt
III. Number of pokes on the papilla during each attempt

Subjective measurements **(score between 1 and 5):**

I. Respect for tissue
II. Time and motion
III. Instrument handling

The expert appoints three grades with a value between 1 and 10 to every trainee, based on their performance during exercise 4. The average of those three grades results in an overall rate for the performance during exercise 4. The three grades are calculated as following:

$$Time\ Grade = 10 - ((A - 10) * 0.075)$$

$$Accuracy\ Grade = \frac{(N * 10 - (1.5 * TP) - (4 * PD))}{N}$$

$$Technique\ Grade = \frac{2 * (RT + TM + IH)}{3}$$

A *= average time of all CBD cannulation attempts [sec],* ***N*** *= CBD cannulations,* ***TP*** *= total number of papilla touches during all successful attempts,* ***PD*** *= total number of PD cannulation during all successful attempt,* ***RT*** *= Respect for tissue score,* ***TM*** *= Time and Motion score,* ***IH*** *= Instrument handling score.*

To prevent biased judgement, the expert that performs the assessment will not know which trainee belongs to which group. Therefore, the sequence in which the trainees enter room 1 and perform exercise 4, is random. For the remaining three exercises the sequence of executing the exercises was assigned, so that the rest periods in-between exercises were equal for every trainee.

4.2 Results

Table 1 depicts an overview of the performance of each trainee during the 4th exercise. The overall grade for each trainee is determined and based on that an overall grade for each subject group can be defined. There are two overall grades for group 1: one that does incorporate the grade of trainee 1A and one that does not. The reason for this is that trainee 1A appeared to have some ERCP experience. Because of this experience, trainee 1A does not meet the criteria for the target group anymore. Including his score could bias the outcome of comparison test.

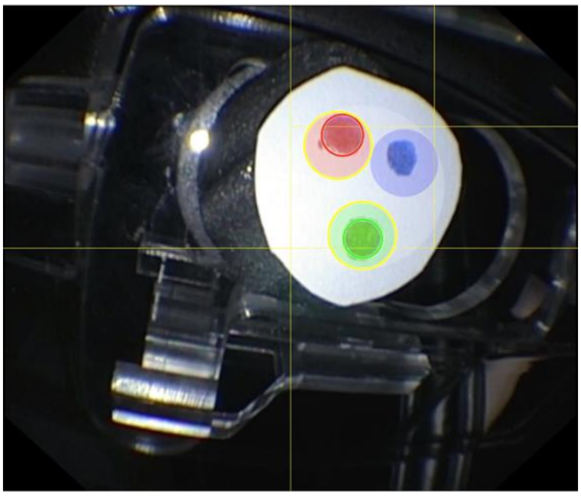


Figure 3 Screen shot of moment in where dot is not recognized, during performance of trainee 1B at exercise 1.

The instructions on how to control the scope did not seem to cause any issues. No struggle or cognitive overload was observed and therefore the provided information seems to properly match the level of the trainees. The first exercise did not seem to cause troubles either. The correct position was achieved numerous times within the set time for the exercise by every trainee. However, one of the trainees complained about the fact that the position was not recognized as correct while the three dots did appear in their target area's on screen (see Figure 3). There are three possible causes for this issue: 1) An error in the MATLAB script for recognizing the objects, 2) the dots are not depicted (drawn) correctly on the paper, 3) the angle of viewing at the papilla is incorrect. As the issue did not occur for other trainees and the papilla does appear to be faced a

Table 1 Overview of the measurements during exercise 4.

			Group 1			Group 2		
			Trainee 1A	Trainee 1B	Trainee 1C	Trainee 2A	Trainee 2B	Trainee 2C
Measurements	Attempt 1	Time	01:10	01:08	02:20	01:08	01:58	01:28
		PD cannulation	0	0	0	0	0	0
		Touch papilla	0	0	4	2	1	2
	Attempt 2	Time	01:09	00:48	00:50	01:12	01:59	01:18
		PD cannulation	1	0	0	0	0	0
		Touch papilla	2	0	1	1	2	0
	Attempt 3	Time	00:37	00:57	00:39	01:25		01:03
		PD cannulation	0	0	1	0		0
		Touch papilla	0	3	1	1		1
	Attempt 4	Time	00:36	00:51				00:59
		PD cannulation	0	0				0
		Touch papilla	1	2				0
	Attempt 5	Time	00:33	00:40				
		PD cannulation	0	0				
		Touch papilla	0	0				
	Attempt 6	Time		00:35				
		PD cannulation		0				
		Touch papilla		1				
	Mean time		00:49	00:49	01:16	01:15	01:58	01:12
Technique (observation by expert)	Respect for Tissue (RT)		3	3	2	2	2	3
	Time and Motion (TM)		2	2	2	2	2	2
	Instrument Handling (IH)		2	2	2	2	2	3
Grades	Grade 1 (Time)		7,1	7,1	5,1	5,1	1,9	5,4
	Grade 2 (Accuracy)		8,3	8,5	5,7	8,0	7,8	8,9
	Grade 3 (Technique)		4,7	4,7	4,0	4,0	4,0	5,3
	Overall grade individual		6,68	6,75	4,91	5,71	4,55	6,52
	Overall grade groups		***6,11***			***5,59***		
	Overall grade groups without Trainee 1A		***5,83***					

little sideways, an improper angle during the positioning seems the most likely cause. However, the blue dot does not appear fully round, therefore the drawing of the dots should be done with more precision

During the second exercise, the trainees struggled with the first advancement of the catheter. It took them a while to perform the first tap on one of the dots (see Figure 4). Yet, this does not necessary indicate improper or insufficient instructions. It can be expected that a new maneuver as such, with an unfamiliar control knob requires some time to get a hold on. During the exercise the trainees expressed their lack of understanding, but without providing additional instructions the trainees eventually all managed to figure it out.

5 DISCUSSION

5.1 Evaluation of the quantitative test results

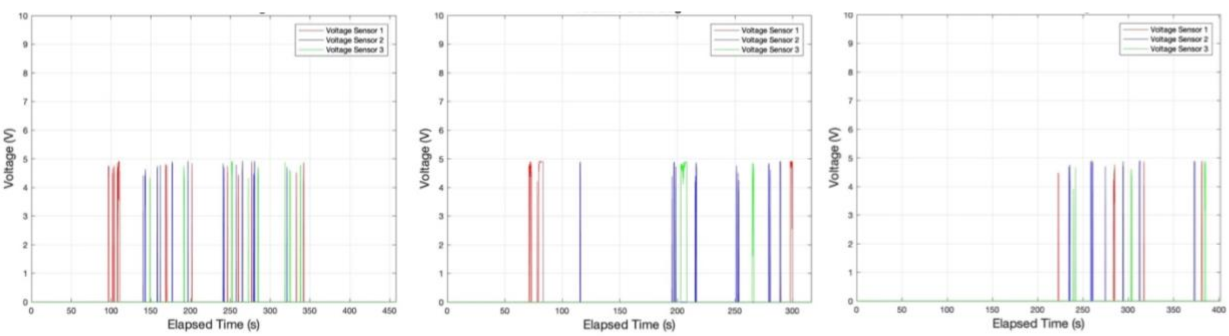
Although group 1 scored better at the last exercise, even without incorporation of trainee 1A's score, the difference between the two groups is very small; a score of *5,83* for Group 1 and *5,59* for Group 2. Due to the very tiny difference and the small sample size of the subject groups, the results are not at all significant. Therefore, the developed program cannot be regarded as an added value just yet, when solely looking at the test results. Unfortunately, more subjects that meet the criteria could not be acquired at the time of testing, due to the limited resources of this "student" research project. To properly examine the effectiveness of the developed training, a similar test with larger subject groups should be conducted.

Even when a subsequent larger study demonstrates significant results, the question remains whether or not the acquired cannulation skills on the ERCP trainer will translate into improved cannulation skills during clinical practice. An additional testing could be done to examine this question, but three studies that examined the translation of cannulation skills on the ERCP trainer and or another mechanical, model to clinical practice when training was provided by a human instructor, already showed positive results [8, 23] [24]. These studies were not for independently executed training, but when both the independently executable program and the simulator itself show to be effective, translation of cannulation skills acquired by the independently executable training on the ERCP training to clinical practice is more than likely.

Returning to the test results, there are some additional aspects that do pinpoint the added value of the developed program, although not proven by the test results. The fact that there is a gaming element involved, automatically results in increased motivation and attention compared to random practice [25-28]. The reasons why this isn't reflected in the test results are that the trainees of the control group did still feel some form of competition and arousal because of the experimental setting and the fact that they knew that their instructor was going to rate their skills at the end. In the normal non-experimental setting of random practice, this motivation and arousal will not be present and therefore their presence during the experiment may have led to biased results. Additionally, the fact that the time for each exercise was very short might have primarily affected the trainees of group 1 negatively, because the assignments that they were given required more time to understand than the assignments of group 2, that just consisted of playing around. Not only did the understanding of the exercises presumably cost more time, but additionally the exercises, in which a certain skill needs to be developed, possibly didn't come into their own for such short practice times. Unfortunately, the time for conducting the experiment was limited, therefore observing and testing for longer periods was not possible. In a further research study, the effectivity should be measured over a longer period.

Passing conclusive judgement on the true effectivity and efficiency of the developed training program may not be possible just yet based on the quantitative test results, this however doesn't mean that using the program is not recommended. As mentioned, simulation training is urgently needed to reduce the risk for the patient and to expand training opportunities. Experts do not have the time to assist during simulation training and therefore trainees should practice on the simulator by themselves. Voluntary use however leads to demotivation since there is no goal to achieve, no check on the performance and no form of competition, and additionally it can also lead to training the wrong tasks and learning the wrong techniques. Implementing a gaming element by definition solves the motivation problem as mentioned before, but potentially also the remaining two issues. Training the right tasks can be

Figure 4 Measurements during exercise 2. Left graph represents the activities (over time) of trainee 1A, the middle graph represents trainee 1B and the right graph represents trainee 1C.



enforced by implementing exercises in the game of which the goal is to achieve competence in a (well considered) selected task. This is done in the developed program by facilitating exercises that cover the defined training needs. Using the right technique for performing the task can also be enforced to some extent, by using realistic and strict criteria for grading procedure success and providing sufficient instructions. In exercise 1 this is obtained by strict criteria for the size, the shape and the location of the marker. The criteria for the size make sure that the distance to the papilla is correct (too large area for example means that the scope is positioned to close to the papilla), the criteria for the shape ensures an en-face view at the papilla (when the area is too ovally shaped, the scope is enfacing the papilla too much from the side) and the location criteria make sure that the papilla is located at the right location on the display (lower left corner of upper right quadrant) and not rotated so that the bile duct is still aligned with the 11 o'clock axis of the enfaced papilla.

5.2 Evaluation of the program based on observations during the experiment

Examining the overall effectivity of the developed training based on quantitative measurements was not the only reason for conducting the experiment. The experiment was also carried out to evaluate the ability of the developed means to properly fulfill the essential tasks of the human instructor, and thereby to facilitate an independently executable training. This is done by observing the trainee's behavior during the experiment and asking for their feedback afterwards. By watching the subjects perform every step of the program, areas for improvement can easily be detected. This way the developed products/exercises can be evaluated on how well they perform as being a stand-alone mean that facilitates training in one of the defined training needs, but also on how well all developed means for the training needs together perform as being a complete program which results in increased cannulation skills

As mentioned before, the provided instructions appeared to be sufficient to successfully complete each exercise. The assessment performed by the means (the developed assessment technologies) served its function to direct the trainees towards the goal of the exercise and confirm correct outcomes. Each trainee was able to complete the program without experiencing difficulties with the execution of the exercises or understanding the provided information and instructions. However, while the separate exercises were executed properly according to the criteria of the assessment technology, not all trainees seemed to understand the real goal of the exercises. It was expected that the trainees would link the acts that they needed to perform in the exercises to the steps of cannulation, but in the second exercise, two of the trainees did not seem to consult the previously learned positioning rules and skills consistently during the catheter directing, and in the third exercise in which the whole act of cannulation was practiced, two of the trainees also did not seem to consult the previously learned positioning and catheter directing rules at all times. Apparently, the goals of exercise 1 and 2 were not linked to the overall goal "cannulation" properly. Although the need for a certain position to obtain successful cannulation as well as the need to guide in the proper direction for selective cannulation, was clearly denoted (by means of illustrations and written text) in the overall instructions and also in the description of each of the exercises, it appears that trainees might neglect that information for executing the second and third exercise. Not transferring the learned skills to the next exercise and not integrating every task into the overall and final task of cannulation, can be attributed to the part-task elements of the training program set-up.

The risk of not integration skills when using part-task training [29][30] was already identified during the construction of the program (see chapter 9.5.1 in the thesis), but the potential negative effects of using part-task training elements were expected to be avoided by implementing aspects of every previously learned skill into the consecutive exercise and by describing in the instructions of the exercise how the exercises relates to the overall goal of cannulation (see chapter 9.5.1 of thesis for more details). These measures apparently were not enough to prevent the non-linkage and non-integration of the tasks.

The issue of not linking or integration the learned skills can, however, possibly be solved rather easily by implementing the assessment technology of the exercises 1 into exercise 2. Because the used measures did not sufficiently impose proper positioning in the second exercise, the act of positioning should be enforced by adding also the positioning criteria to the set requirements (for the assessment technology) for accrediting success. For practicing the combined act of cannulation in exercise 3, a technological assessment mean has not been developed just yet. Considering the neglection of the positioning rules when not assessed on, it is recommended to also implement the technique of object detection in this exercise. The location of the marker (dots) on the papilla need to be changed to make cannulation possible. Additionally, also warnings signs can be inserted into the exercises. Since the attention of some trainees cannot be caught during the instructions, signal needs to be given during the exercise. A warning signal containing a question such as "is your scope in the correct position in front of the papilla?", may be inserted during the exercise as a display confiscating message or audio/video message, and thereby pausing the exercise for a couple of seconds. During the cannulation exercise (exercise 3) these signs should also contain the question "did you direct the catheter towards the correct axis? (11 o'clock bile duct, 2 o'clock pancreatic duct)", to make sure that the information of the previous scope direction exercises is consulted during the selective cannulation.

5.3 Remaining points of discussion

It could be argued that the expert teacher could also be replaced by another non-specialist human instructor. This however would bring along several issues: The amount of training that trainees receive is still subject to the availability of the instructor since trainees cannot train on any given moment because of the need for an instructor to be present as well. Also, it is questionable whether or not the replacing instructor is objective and sufficiently competent to properly execute the tasks of the expert instructor. Therefore, it was decided to use technological means for the replacement of the instructor tasks.

6 CONCLUSION

The overall impression of the training's set-up and adequacy in meeting the objective and facilitating the needs while also properly replacing the essential tasks of the human instructor to remain effective and efficient, is predominantly positive. Although the effectiveness of the of the training relative to random exposure was not significantly proven, due to the limited sample size of the subject groups and the small measured difference between control group and intervention group, multiple other elements (e.g. increased motivation and attention due to gaming element) emphasize the added value of the developed training. The developed program moreover covered all the essential training needs, the pre-defined instructions showed to be effective in supplying all the required information for performing the exercises properly on an independent basis, and the developed technology for providing the required feedback, assessment and documentation during the exercises, also showed to function adequately.

Overall it can be concluded that developed training could, with some slight adjustments, be a solution to the urgent need for a save ERCP training that is affordable and available to the trainees at any time. The recommended adjustment is to implement measures that promote the transfer and integration of learned skills into a subsequent task and link the goal of each game to the overall goal of cannulation, in order to avoid the possibility of negative transfer and developing incorrect techniques. The proposed concept for realizing this is to tighten up exercise 2's criteria for success by adding the assessment technology and criteria of exercise 1 to exercise 2. The techniques for providing assessment and feedback in the means for exercise 1 and 2 can also be used for the third and final exercise in which the combined act of positioning and catheter advancement, which results in cannulation, is trained.

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