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RESEARCH ARTICLE

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Introduction of a Blood Group Serological Device
– Evaluating the Product Development Process Based on User Needs

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Abstract

Blood group serological medical devices produced in Hungary are in the focus of this paper. The first Automatic Coombs Test Analyzer (ACT) was constructed approximately 20 years ago. There is a huge competition between the blood group serological devices applying different types of techniques (e.g. microplate, card or spin tube technique) which can carry out all the applied methods (e.g. direct agglutination, enzyme, antiglobulin or Coombs, or Polybrene method). Therefore, the continuous development of such an instrument is inevitable. Involving users can result in ideas that may have serious impact on the product development process. Within the confines of our research five focus groups including thirty-five participants from three Hungarian laboratories were conducted in order to gain user opinions and expectations regarding the Advanced ACT. As a result the optimal ratio between automation and being able to control the results manually was pointed out to be a crucial factor of the users. A possible solution was shown to eliminate or at least decrease the potential stress mentioned by them.

Keywords

Product development · Innovation · Automation · Focus group · Blood group serology

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1 Introduction

In the field of blood group serology a huge amount of measurements are performed under different working conditions and according to diverse subjective laboratory routines. The daily number of samples, their arrival to the laboratory, the timeframe a laboratory has for processing them, the number of employees and their qualification raise quite different needs that can only be satisfied with a wide range of laboratory devices.

Seven multinational companies offer blood group serological devices in the international market. All of these have their own closed system (differing from the conventional serology) that includes disposables.

Closed systems dominate the market, but the spin tube technique is also needed on the one hand due to professional reasons (since it is considered to be the so-called 'golden standard'), and on the other hand due to its remarkable cost-effectiveness.

The spin tube technique (which is an open system) served as a base for the elaboration of the whole field of blood group serology at the end of the last century. It has been automated in Hungary by only one company. The device produced by them is called ACT (which stands for Automatic Coombs Test Analyzer). Its competitors elaborated novel serological circumstances for their disposable tools, which contributed to the high costs of the tests done by them.

The article is based on the ACT product line which uniquely helped to spread the cost-effective tube technique of the field of immune hematology by means of automating it. The continuous developments of the ACT automatic instruments provide a remarkable cost-effectiveness (regarding the price of the device and the tests) together with the same quality of measurements.

The measuring method for blood group serological tests, based on photosedimentory, has been worked out uniquely by the company mentioned above. They elaborated and spread the agglutination analyzer called ACT-24 widely in the Hungarian transfusion diagnostics.

Through the years trends have shown the increasing need for automated instruments in contrast to the earlier manual blood group serological measurements. Faster and more automated devices were and are demanded both nationally and internationally.

Beyond the faster sample process another advantage of the automated instruments is that they can carry out the steps of the analysis (e.g. pipetting, incubating, centrifuging, reading etc.) in such a precise way that they lead to far fewer doubtful results which need to be overwritten by the users. As a consequence the responsibility of the user is smaller and fewer repeated measurements (thus e.g. fewer test cells) are needed.

A new blood group serological instrument was invented as a response to the demand for the automation of the tube technique. The main point was to keep all the benefits of the tube technique and at the same time to eliminate the false results caused by human error by means of reaching a higher level of automation.

Automation and the opportunity of checking the results manually are core questions in case of modern serological devices with tube technology. One of the reasons is to be able to detect human error, and the other is that the users should also be able to detect the possible technical errors of the device. The key issue is to have the control over the secure operation of the instrument, meaning to have the opportunity to choose between operating automatically and manually, since an error (committed either by the user or the device) may lead to a threat to life.

1.1 Advantages of the conventional spin tube technique

1. All the scientific background of modern blood group serology was developed by means of the spin tube technology.
2. All the known antibodies were discovered by means of the spin tube technology. (There is not one antibody-antigen system that was discovered by means of gel cards.)
3. Only by means of the spin tube technology can *all* the known methods (Coombs, enzyme, PEG and Polybrene) be performed.
4. The spin tube technology combined with sedimentation analysis can analyze the size of the particles in the easiest way; no foreign phases are used.
5. It can be used together with reagents from different sources: the uncertainties can be limited by taking advantage of the different biological background of the reagents.
6. The patient's and the donor's samples are used in their natural liquid state; there is no need for bounding them to solid phase.
7. Presently it is the cheapest known technique.
8. The professionally performed tube technique is considered to be the 'golden standard' up to this time.

1.2 Disadvantages of the conventional spin tube technique

1. The proper manual use of the tube technique can be learnt with some difficulty. Subjective sources of errors can be: reading the results and gently shaking the tubes manually. (These risks can be eliminated by automating the measurement which has already been carried out in case of the ACT product line.)
2. The perfect cell washing should be carried out in case of each measurement by means of proper devices of high quality. (In case of gel cards the possibility that cell washing errors occur can be prevented by high quality production technology. The Advanced ACT Robot (see below) is a solution for this problem.)

The reason for the continuous improvement of the ACT product line is that according to most experts the liquid phase sedimentation analysis is the most suitable technique for detecting agglutinates, for measuring in a semi-quantitative way, and for detecting hemolysis as a side phenomenon.

Techniques applied among the competitors of the ACT product line are based on similar principles, but using a different medium (e.g. gel column) has more disadvantages relating to reading the results: they are slower and more expensive. However, their additional advantage is that cell washing in their case does not require huge instrumental work, 'only' the proper quality insurance of the production of the gel cards.

This competitive disadvantage had to be eliminated by the small-sized company producing the ACT product line by means of improving the cell washing to make it absolutely reliable. In case of the improvements mentioned before the competitive advantage of the easy measuring (namely all of the blood group serological measurements can be performed according to the highest quality standards in the same way by means of ACT automats) could be used.

2 Product development and innovation 'Innovate or die!'

Innovation is a competitive advantage that means an intentional process of new products that satisfies or generates new needs (Lógó, Süle [4]). Innovation is a new combination of production factors (Schumpeter [7]). In our case (innovation of a new blood serological device) the type of innovation was the development of a new product, in the physical scene too. As Schumpeter [7] states, a basic feature of innovation is the economical applicability, thus a new product is not an innovation unless it is economically applicable. As a result of this feature financial and marketing aspects should also be included in the product development process.

Product engineering and product development means the process from an idea to the materialization of a new product. Product development is a broader concept that covers the process from the seeking for a new idea as far as the introduction of the new product to the market. Finally product innovation also covers a wider perspective from the company's strategic decision through the product development to the research of user experience and feedback of these to the company (Lógó, Süle [4]). In this sense I would like to introduce the new blood group serological device (called Advanced ACT) in the frame

of product innovation. This article covers the research of user experience, and the conclusions of this process.

The development of the new device is a strategic process that should include the analysis of the company's current position in the market (both strong and weak points and competitors) and also the analysis of the inner structure of the company and the expected changes, tendencies of the product and its users (Lógó, Süle [4]). These factors are combined in the product strategy which describes the values and function that the new product should incorporate. A function of a product is not a single construction but it is a complex combination of technical, economical and also psychological factors (see Table 1).

Tab. 1. Product functions (Lógó, Süle [4])

Technical function	How it works
Psychological function	Product experience, emotions connected to the product
Sociological functions	Social meaning of owning this product
Economical function	Economical acceptability, mainly the price of the product
Documentation function	A product from the past describes the era when it was used
Environmental function	Products' relation to nature

It is important to take into consideration that the previously collected product functions are not equally important for the users and for the company. As a result a product could be described as an onion built up from layers on each other (Kotler [3]). In the center of this concentric system the product core can be found that holds the basic utility of the product. The product core is what the product is for: the satisfactory solution of the basic need. Further in the other layers there are products expected or extended or potential products that are based on consumer expectations, brands, consumer service experience and price.

From the perspective of marketing the following questions must be answered in case of a product: (1) *Whom does the product serve?*, (2) *What can the product be used for?*, (3) *What are the features of the product?*, (4) *What is the reason to buy this specific product?*, (5) *What does the product mean for the customers?* A product concept in the strategic meaning should include all these questions mentioned (Rekettye [6]). The task description includes the functional and technical information that must be included in product development for a specific purpose.

In the product innovation process, as mentioned above, the feedback gained from the users and customers are essential to be included. Before the introduction to the market a prototype of the product should be tested by involving recruited potential (expected) users. The experience from the presentation and testing of the product can serve as important feedback for further corrections of the products, to reach the satisfaction of both the users and the company.

One of the key aspects of product development and innovation is ergonomics and the ergonomic quality of the product (Antalovits [1]). The user-focused product development emphasizes the ergonomic features because this means a design for human use. In this process the users should be included in the development already in the planning phase: their expectations, physical parameters, knowledge, needs, task work features and security reasons. In the testing of the product prototype the user experience, the feedback of usability testing and opinions are key features for the development process. In the marketing phase the information gained from users about the product should serve as main messages emphasizing the strength of the innovated product. From the perspective of ergonomics a well-designed product (among others) should keep the error rate low, help to prevent user errors, let the user correct the committed errors easily and take the users' actual skills and capabilities into account (Antalovits [1]). The three key features are (1) safety, (2) efficiency and (3) comfort of usage (Antalovits [1]). The order of mentioning these features reflects their priority rank. Safety is the possibility of operating the product (in our case for a blood serological device) without errors which could threaten certain persons' (in our case patients') health. Efficiency means that the users can use the product with little physical or mental effort and without errors. This is strictly connected to the fit of the device into the users' physical, mental, and psychological parameters and also to the work processes. Finally the comfort of the product means the positive emotions towards it including the esthetics and social attraction.

From the point of view of safety it is important to consider what kind of errors can happen, what the possible consequences of these errors are, and what the probability of these errors is (Geri, Süle [2]).

3 Blood group serology – methods, techniques, history

To be able to have a closer look at the market of blood group serology, first of all the methods and techniques used in laboratories should be mentioned.

3.1 Methods

Methods are the circumstances of reactions determined chemically and/or biologically which help the antibodies and antigens bound. These methods were elaborated during the last century as part of the scientific principles of blood group serology in order to be able to discover all the important antigen-antibody systems.

All of those methods together with their opportunities and limits were elaborated before 1960. It can be stated that there

has not been any competition in the field of applied methods for decades.

But there is a serious competition between the blood group serological techniques which can carry out the mentioned methods.

A specific method can indicate only a definite group of antigen-antibody systems. There is not one single method that could be used for all the antigen-antibody systems, so it can be stated that more methods should be used parallel for an overall measurement. In contrast to this there are several techniques which can carry out all the methods.

The most well-known methods are the following:

- Direct agglutination method
- Enzyme method
- Antiglobulin or Coombs method
- Polybrene method

3.2 Techniques

Grouping by chronology

- Earlier techniques
  - Slide technique (it can be used for direct agglutination method)
  - Spin tube technique (it can be used for all the methods mentioned above, it is universal and is called the 'golden standard')
- Modern techniques
  - Sedimentation techniques (e.g. ACT-24, DiaMed, ScanGel, Grifols etc.)
  - Immobilization techniques (bounding to solid surface instead of agglutination)

Grouping by appearance

- Automatic tube technique (ACT-24: it can be used for all the methods mentioned above, it is universal and represents the 'golden standard' as mentioned above)
- Microplate technique (it can be used for all the methods mentioned above by means of using magnetized red blood cells or immobilized reagents on the wall of the microwells)
- Column technique (it can be used for all the methods mentioned above)

3.3 History

The date of the discovery of different blood groups and the names of the methods and techniques can be seen in the following picture.

First solutions to avoid subjective errors can be seen in the following picture.

The first automats can be seen in the following picture.

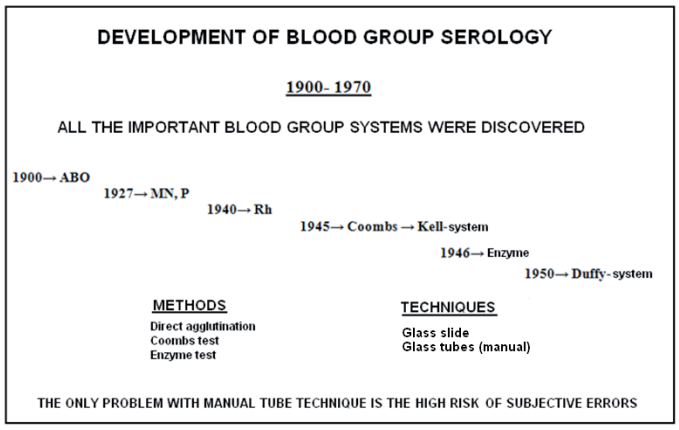

Fig. 1. Development of blood group serology

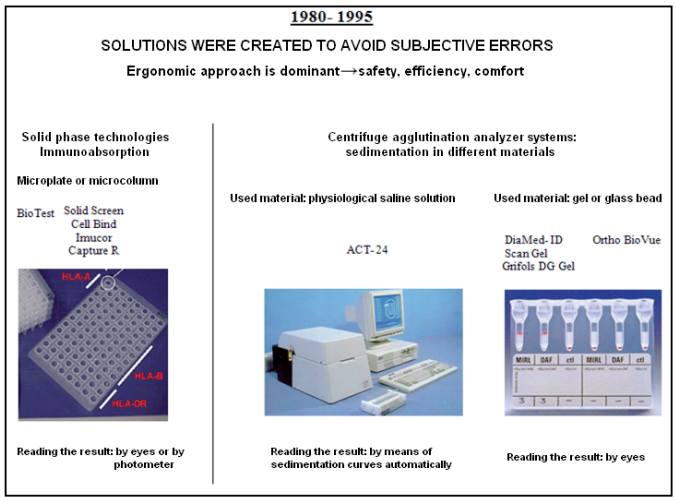

Fig. 2. First solutions to avoid subjective errors

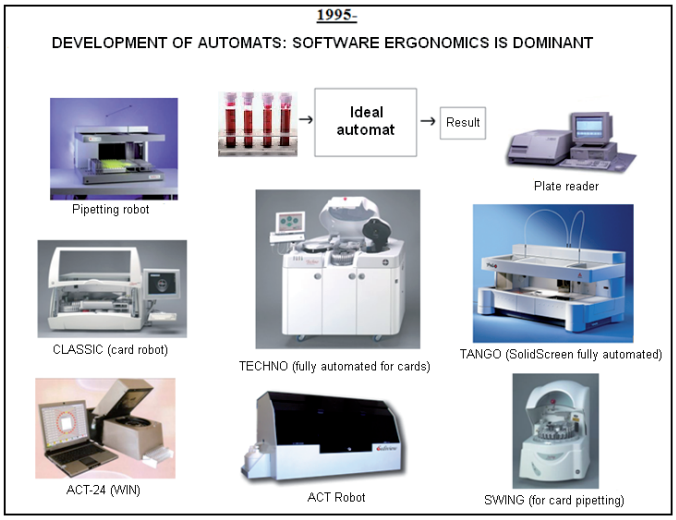

Fig.3. First automats

4 ACT product line

The first blood group serological instrument made by the only Hungarian company that offers automats for measurements in the field mentioned was the so-called ACT-24. It combines the conventional spin tube technique, which is the generally accepted reference method for antibody screening, with a degree of automation. While the sample preparation is still being done manually, the AHG-dispensing, washing, diluting, centrifuging, as well as the reading, displaying, printing and archiving of the results is computer controlled, thus providing a standardized processing procedure.

After the first series of ACT-24 semiautomats the company launched a continuous development. First they developed the first model of ACT Robot. The ACT Robot is a fully automated system which uses the "golden standard" spin tube technique. Its main advantage is that it can carry out any kind of tube test. It adapts to the needs of the customers by making it possible to program any variation of methods and applications. The instrument is an open system; the reagents of any company can be used in it. It works with disposable plastic cuvettes, which has to be replaced after every run (Cytotech Ltd.).

At the end of the year 2012 a new situation occurred due to the fact that the construction of the fully automated, "walk away" system the Advanced ACT Robot was finished.

The company also had to compare the disadvantage of the delay due to the production of the Advanced ACT to the benefits of the "walk away" construction in order to decide which model should step into the world market first (the ACT Robot or the Advanced ACT).

The differences of the advanced and previous model are detailed below.

4.1 Technical comparison of the existing and the advanced models

Descriptions and facts can be read first and *remarks* follow in italic.

The existing model (ACT Robot) is in continuous routine use in different cities in Hungary. The prototype of the Advanced ACT has been built.

Since 2008 the company has had the opportunity to involve user needs in the product development process since they had won a tender and from this they could cover the expenses of different user-focused researches.

In 2008 and 2010 several focus group analyses were conducted (partly by the author), however here this paper concentrates on the ones conducted (again partly by the author) in 2012. The main reason to do so is that the Advanced ACT was tested among users only in the frame of these latter focus group sessions.

5 Empirical research

5.1 The goal of the study

The goal of this study is to present the main results of this user-focused product development process of the Advanced ACT model. I am going to focus on how in this process the innovation included the users' opinions and expectations and in what particular ways the latest version of the ACT device could provide the users with relevant answers to their former expectations.

5.2 The focus group method

The focus group is a popular qualitative research technique in social sciences as a special form of group interview (Szokolszky [8]). At the same time it is also a widely used research technique of the field of user-centered product development. Usually the groups consist of 6-12 carefully recruited participants. The members of the group discuss a specific subject (in our case the ACT Robot and the Advanced ACT blood group serological devices). The discussion is moderated by the group leader (called 'moderator').

In the group discussion the participants share their opinions, emotions, and experience about the presented devices. The group discussion as a social setting facilitating the openness, the smooth communication and the spontaneity of the participants. These advantages justified the selection of the focus group technique in this research presented. This group interview technique usually produces more information as results than that a classical, one-to-one interview may produce. The qualitative analysis of focus group discussions serve as a basis for the further development and marketing of the Advanced ACT device.

The leader of the focus group has to control and focus the flow of the group discussion. The moderator makes sure that all members can share their opinion and none of the members dominates the group discussion counterproductively. In this way the moderator's role is to facilitate the interactions and opinion sharing among participants. The moderator as a leader has to communicate the group's frame of working the operating rules and the goals. A focus group is a proper and unbiased tool for data collection concerning the opinions related (in our case) to the mentioned blood group serological devices when it is conducted with defined goals including the important topics and when the atmosphere is open for communication.

The selection of the focus group participants is based on their common interest and experiences in general. In our case we have selected the users and potential users of the tested devices to participate in the focus groups. This paper presents only the results from those groups where the participants actually use an ACT Robot in their daily practice. This selection strategy allows the collection of real user experience.

Tab. 2. Technical comparison of the existing and the advanced models

Features	ACT Robot	Advanced ACT
Software	Difficult to modify, extended tests are necessary even after minor changes. Not flexible.	Flexible module software system based on industrial robot controller algorithm.
Serological performance	Highest quality of reading *Results given by this model are equal to the new system* *Hemolysis: checking visually*	Highest quality of reading *There are no changes in the evaluation principle, but the appearance of the doubtful results is minimized.* *Hemolysis: automatic checking*
Construction (general)	The reactions are prepared directly into the cuvettes of the ACT rotor. Centrifuge rotors with contaminated cuvettes are replaced manually for cleaning. *The ACT units are occupied for the time of dispensing and incubation as well.* *2pcs of ACT units are necessary*	Separate dispensing discs are available for dispensing and incubation. The built in centrifuge rotor is loaded with the (incubated) samples automatically from the dispensing discs. The cuvettes are cleaned automatically between cycles. *ACT units can continuously work, consequently a new system with a single ACT unit can be 1.5 times more effective than the previous one (with double ACT).*
Decanting system construction	Decanting probes with lifting mechanisms and with multi channel vacuum pumps. *Mechanically sensitive, higher risk of reliability.* *Relatively slow.* *One drop of residue unavoidable: appropriate for cell washing, but not really for cleaning cuvettes.*	Advanced construction for centrifugal decanting. *More robust mechanism.* *Quick.* *Possible to dry the cuvettes by centrifugal force.*
Incubation	In ACT units	In inner incubator
Number of ACT units	2 pieces *Not possible to double*	1 piece *Possible to double*
Number of rotors	Min. 4 replaceable	1 fixed piece
Changing cuvettes:	Options: – replacing one by one: – disposable or – washing – washing the whole rotor in a special machine. *There are concepts for developing a washing machine, but none for a quick dryer.*	Fixed cuvettes with automatic washing and drying
Disposables	Cuvettes EUR 70/1000 tests	No disposables
Velocity (AGT/8hours)	580	940
Walk away	User must change rotors after every 36 tests. *Optimally a pair of rotors can be replaced at the same time. One hour walk away time in the case of AGT*	Up to 8 times longer walk away time.
Dimensions (mm)	1000x500x500	700x600x500w
Weight (kg)	50	60

5.3 Participants

The participants of the focus groups presented in this study are users of the ACT Robot blood group serological device. The five focus groups conducted included thirty-five participants from three laboratories (from Kecskemét and Budapest) using the ACT Robot device. Six participants are physicians specialized in blood group serology; there were three executive assistants, and twenty-six assistants from the laboratories.

The group size varied from six to eight people depending on the availability of the participants. The participants were mixed from different laboratories in order to facilitate the discussion and sharing of experience across institutes.

A group session took in average 2 or 2.5 hours, which was video recorded and noted. The scenario of the focus group started with the introduction of the participants and the presentation and acceptation of the group roles. Then it went on to the collection of experience about the ACT Robot blood group serological device. The opinions and experience mentioned in the group discussion were noted on flipchart by the group leader and then assumed by the participants when they summed up the conclusions. The next part of the group session was the presentation of the prototype of a new ACT blood group serological device (the so-called Advanced ACT) in physical reality including technical data specifications and an interactive demonstration of its work process. The participants had the opportunity to watch a whole 40-minute-long measurement process of the device and also questions could be asked. After this session the group settled to collect the opinions about the new ACT device presented previously, especially focusing on expectations.

5.4 The room and place of the focus group

As a part of the product innovation process the targets of the conducted focus groups were the experts using ACT Robot devices and among them the expected users of the Advanced ACT blood group serological device. In order to avoid biased opinions the focus groups were conducted in a meeting room of an independent company producing serological accessories (Reagens Ltd. Budapest) instead of the office of the developer company (Cytotech Ltd). The room of the focus groups was isolated and calm enough to provide an open atmosphere for opinion sharing. The participants sat down around a table in the middle of the room. They received pen and paper to take notes and the leader of the group used a flipchart to collect the opinions in a structured way visible for all. In the room there was one ACT Robot and one Advanced ACT device placed. Both were possible to be inspected and this way they served for elicitation of experience and ideas in the group sessions. The physical setting of the groups is presented in the following figures.

Focus group participants during a discussion can be seen in this picture. The group moderator was summarizing the opinions on the flipchart.

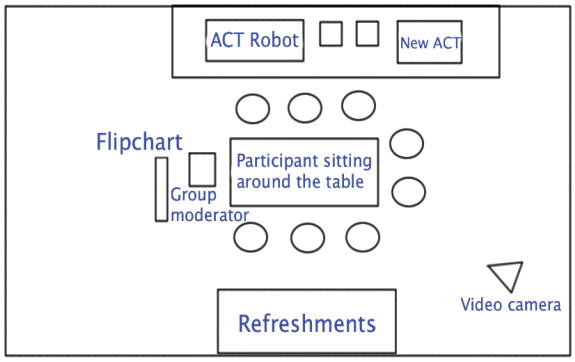

Fig. 4. Physical setting of the groups

Fig. 5. Layout of the focus group room

Fig. 6. The Advanced ACT device (from outside)

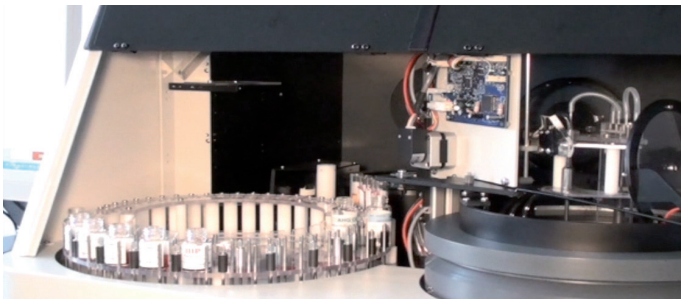

Fig. 7. The Advanced ACT device (from inside)

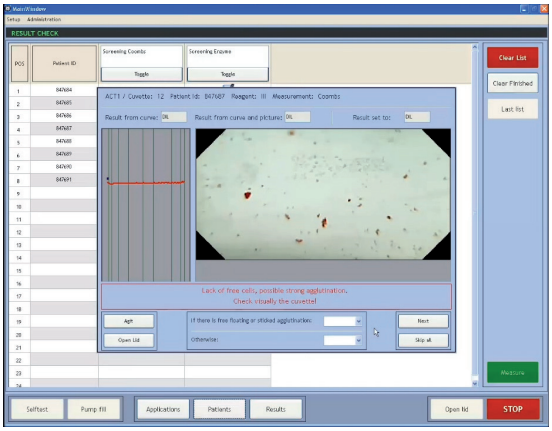

Fig. 8. The software interface of the Advanced ACT device

6 Results

Of the results only the product development process related data are presented here. The recorded videos and flipchart notes are analyzed qualitatively. In this section I am going to focus on the questions raised about the ACT Robot (from user experience) and I am going to compare them with the possible answers found in the presentation of the Advanced ACT device. With this structure the study aims to show the key points of the product development process which reflect to user opinions and needs. But this reaction to user needs can also be exaggerated which leads to focusing on one problem while other problems develop as a side effect. The main purpose here in this study is to show that the permanent application of the product development goals and strategy would help to keep the balance among the different user opinions.

To be able to see why the devices mentioned below are compared with each other it has to be emphasized that the development of the new Advanced ACT device was mainly motivated by the automation of the manual work processes in case of the ACT Robot (see Tóvölgyi, Hámornik, 2013).

6.1 Questions and answers

Table 3. presents the questions raised by the ACT Robot device and previous ACT devices paired with the answers provided by the new ACT device as a result of the product development process.

6.2 Opinions about automation

Automation appeared to be a two-folded concept in this section (see Tóvölgyi, Hámornik, 2013). On the one hand, the automation of the blood group serological measurement process helps to save time and effort for the users. However, on the other hand, the automation as a process running freely with no need for human action led to the feeling of lack of control over the measurement process. Lack of control is first of all a question of safety: is the automated process reliable enough. Secondly automation is a question of competences and the users' feeling of usefulness including all levels of the laboratory staff. The participants mentioned that the automation of the Advanced ACT device saves time for them (*'the machine does the cleaning of cuvettes; it can be loaded continuously, etc.'*). But the very same participants mentioned that this automated process is closed for manual validation, correction, inspection (*'the results cannot be controlled manually, the process cannot be interrupted, thus the questionable results remain uncertain'*), even though the user (physician or assistant) is responsible for the result of the measurement (as a medical decision).

This leads to a new question that is to be analyzed more thoroughly: is there a substantive difference between the two tendencies? The manual spin technique used to be the only technique carried out manually and checked visually. For those, who are professional considering this technique, it has always been the most efficient and widely used technique. All the automated systems decrease the feeling of being able to control the processes, but at the same time it means to simplify the laboratory routines. And in the daily laboratory routine it is expected by the users that a device can carry out the whole process by itself. There are only a few physicians or assistants who really are interested in having a closer look at the results with their own eyes.

This could lead to a new and interesting study where phenomena, such as indirect sensation (e.g. not trusting the rear-view mirror while reversing the car and because of that turning one's head backwards), could be analyzed.

7 Conclusion

The results presented here show a heterogeneous picture of user opinions. The need for automation is satisfied during the steps of the innovation process, but at the same time a new kind of dissatisfaction feeling has come up. On the one hand, due to the full automation the users are not provided the opportunity to control the measurement which in some cases can cause dissatisfaction and new user questions. On the other hand, the development process answered several questions gained from earlier user opinions that facilitate safety, utility, and comfort which have led to a higher level of usability and satisfaction.

In order to avoid or at least decrease the stress caused by not being able to control the results manually, the video camera integrated in the Advanced ACT device had to be upgraded, so that it can record the reactions in the cuvettes and can capture the bottom of the cuvettes, too. Due to some innovative development the new camera is capable of doing so. By means of these videos the users can have an almost realistic picture of the results, thus not being able to take the cuvettes out of the machine due to its closed structure may be less stressful for them. These short videos are kept by the computer connected to the Advanced ACT device, so that they can be checked over and over again any time by the users.

The innovation process and the product development process of Cytotech Ltd. should be strategic in the future as well

Tab. 3. Questions raised by the ACT Robot device and previous ACT devices and answers provided by the new ACT device

Features	Problems and questions related to the ACT Robot and previous ACT devices	Answers provided by the Advanced ACT device
Cuvettes	The disposable plastic cuvettes are generating permanent costs and environmental load.	The plastic cuvettes are replaced by reusable glass cuvettes.
	The variations in the thickness of the walls of the plastic cuvettes lead to ambiguous results (the variations are caused by the manufacturing of the cuvettes'), causing ambiguous sedimentation curves.	The quality of the glass cuvettes is better, and the walls of them are homogenous, thus no ambiguity is caused.
	The manual cleaning of cuvettes is not reliable.	The automated device cleans the glass cuvettes, and the testing results show that this cleaning process is effective enough.
Quantity of (blood) samples processed a day	The ACT units are not operating during the preparation and incubation phases and this limits the quantity of blood samples processed a day.	Except for the first running of the day the device operates continuously: there are samples in both the rotor and the incubation area. The full automation keeps the device in non-stop operation when it is continuously loaded with samples.
The holder clips of the reagent substances	Due to the permanent removing and exchange of the reagent substances, the plastic holder clips were frequently broken.	The new holder clips are made of more flexible material in order to prevent breakage.
Sedimentation curves	The users rarely base the results on sedimentation curves; they even prefer not to learn the interpretation of these curves.	The incubation and the examination processes are now separated physically thus the curves are more reliable and more applicable.
	Incubation sometimes distorts the curves.	
Video camera	The picture taking process is slow.	A new camera device is built in which is faster and more reliable.
	Sometimes the camera takes low quality or even unusable pictures.	
	Due to the position of the camera the reactions at the bottom of the cuvettes were sometimes invisible to the camera since the bottom of the cuvettes could not be captured by the camera.	The new camera captures the bottom of the cuvettes, too.
The shaking of screening and test cells	The manual shaking of the screening and test cell bottles is time-consuming and demands human labor capacity. The skipping of the shaking process may lead to ambiguous results in which case the test must be repeated.	The fully-automated device shakes up the cells before every test.
Questionable results	The automated measurement stops when it finds a questionable result, and it does not go on unless the user manually validates it.	The fully-automated device continuously processes the blood samples and stores the questionable results for further validation. It does not stop for validation, so it can be done at any time without interrupting the measurement process.
The size of the device	The size of the ACT Robot is relatively extensive compared to the crowded laboratory conditions in Hungary. (1000x500x500mm)	The new ACT device is smaller (700x600x500mm) which provides a better fit in the laboratory settings in the market.
Design	The users of the ACT Robot are not content with the esthetic features of the device.	The user opinions (e.g. doors, and opening mechanisms) were taken into consideration when creating the design of the new ACT device.

(like it was in the last 5 years) in order to keep its focus on and mutual feedback with the actual and potential users.

The producer of the ACT product line has been able to carry out the following: 'innovate *systematically* or die' – our opening sentence modified. In their case innovation has been an essential tool in being able to survive the economic crisis over the last years. Continuous improvement has become one of the main corporate competences. As a possible consequence of this attitude the company has recently signed a memorandum of understanding [11] about new projects with the Kuwait Life Sciences Company, which is fully owned by the National Technology Enterprises Company (NTEC); a Kuwait Investment Authority (KIA) fully owned company [12] (Hungarian Government). This user-centered product development process may serve as an example for other companies.

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