DEVELOPMENT OF THE MOBILE APPLICATIONS FOR USING IN APPAREL AND SHOES DESING

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Abstract: *The globalization of the fashion clothing and footwear market, the significant influence of social networks and the speed of the spread of fashion trends require the presence of appropriate mobile technologies in the arsenal of a light industry specialist. Having analyzed the market of mobile applications in the field of shoe production, it has been singled out that there is the lack of applications that provide the calculation of details of shoe design and allow maintaining distance learning conditions for students in the industry. The similar conclusion was made for the field of apparel design. The aim of the study is to develop mobile applications to support the process of shoe and apparel design using computational and graphical methods of construction. The initial information on the construction of shoe and garment designs has been structured. The method of construction has been transformed into a tabular form by selecting elementary graphical operations; each one has been described by an attribute tuple. Modular synthesis of the structure for step-by-step presentation of information in the mobile applications has been applied. The implementation of step-by-step layering of structural modules by the principle of modular synthesis has been performed using the mechanism of on and off layers in the environment of the graphics editor. The method of semantic differential has been used to evaluate the developed mobile applications. The scales of the semantic differential for each attribute of the mobile applications have been represented as bipolar pairs expressed by adjectives or adverbs. The resulting psychographic profiles of the applications indicate a positive assessment by experts, as the coefficients correspond to the positive values of the Kansei words. The developed applications are intended for use by teachers and students of higher educational institutions, representatives of shoe/apparel companies, pupils and teachers of colleges, technical schools. The results of a survey of students and teachers have confirmed the need for the introduction of a mobile technology.*

Keywords: *mobile applications, design calculation, shoe details, garment parts, psychographic profile, modular synthesis.*

1 INTRODUCTION

The globalization of the fashion and footwear market, the significant influence of social networks and the speed of fashion trends require the presence of appropriate mobile technologies in the arsenal of a light industry specialist. The cost of ready-made applications is hundreds of times less than the cost of pattern-design systems (PDS) systems for clothing or footwear. The cost of their development and its duration is also significantly lower than the corresponding indicators of PDS. This allows providing the digitalization of small businesses, studios, showrooms, for which the purchase of industrial PDS is economically unprofitable. The use of applications does not require any costs for the purchase of equipment. The percentage of the population of any country in the world that uses mobile and tablet devices has reached its maximum level in recent years. Therefore, mobile technologies are relevant both for light industry enterprises and for educational institutions of all levels. This trend, as well as the presence of cameras in mobile and tablet devices, allows you to use them as a digital camera or even as a 3D scanner.

It should be noted that a designer of clothing or footwear, working in mass production, has long moved its workplace in the virtual space of computer-aided design systems. However, a student who is just mastering the profession and his teacher work manually or semi-manually. This is due to the peculiarities of studying the process of construction. To solve such problems, PDS is also a very expensive tool, which, moreover, does not have the necessary functionality. Calculators, although, are quite convenient for this type of task, but this calculation takes a long time, and the number of manipulations increases the risk of errors. An additional factor in favor of the use of mobile technologies is that there is the need in education to introduce distance learning, which is now faced by all educational institutions in the world due to the COVID-19 pandemic.

2 ANALYSIS OF PUBLISHED DATA AND STATING THE PROBLEM

The possibilities of using mobile applications for learning or as a tool in the learning process are widely covered in the scientific literature. Pedagogical and technological advantages of mobile learning are recognized by scientists and teachers [1]. Such studies have been conducted in various fields, such as: interactive learning environments for children [1, 2], training in clinical medicine [3, 4], language learning [5, 6], the study of physical phenomena using smartphones [7-10], etc.

Some advantages and disadvantages of using smartphones in training modules, such as learning identification skills in the field, are described in [11]. It should be stated that no evidence has been found that mobile technology has improved students' ability to apply their skills in the field. However, students have told that one of the advantages of mobile technologies is the ability to access the necessary educational information even in extracurricular activities.

In work [2] it has been found that learning with the use of tablets in comparison with traditional methods provides better learning outcomes for students and at the same time better meets the needs of teachers. Similar conclusions have been obtained as a result of studies presented in work [1], in which in addition to the use of smartphones, robots are used for training. That in total has provided significant optimization of mobile learning.

The most widely used mobile applications are in the field of language learning and teaching [5, 6] and this includes even the languages of formal programming languages [6]. Work [6] shows that such applications not only provide students with answers to their questions related to specific topics, but also provide an organization of the learning environment that supports the step-by-step learning process. Works [5, 6] are devoted to the analysis of various mobile applications used for learning foreign languages. The analysis has revealed that the quality and feasibility of individual tasks in different applications are not the same. However, as a rule, students who take part in research express a positive attitude towards such learning tools.

Mobile applications in the footwear industry, described in the scientific literature, are often associated with the production of smart shoes, such as shoes for the blind [12]. The developers have built sensors into the shoes, which transmit a signal through the Arduino board (Italy) to a smartphone that has an application for the Android operating system (the USA). The clear advantage of such an application is the ability to work without an Internet connection.

Another example of the use of mobile applications for smart shoes is the smart navigation technology described in [13], built into shoes for bikers and cyclists. The application for the Android operating system allows you to choose the best way to your destination. Studies dedicated to determining the best technologies for scanning the feet using mobile applications are presented in [14-16].

In [14] the approach to the estimation of the three-dimensional shape of the foot using a mobile application is described. The application algorithm finds a combination of shape parameters that best match the foot parameters that are determined from the photographic image of the foot. The mobile application offered in work [15] acts in a similar way: the photographic images of the foot are determined by six parameters of the foot, which users can use to select the right size shoes.

The aim of the study [16] was to determine the consistency between two 3D scanners, the software of one of which is actually a mobile application with the iOS operating system (the USA). The paper proves that the reliability of the data obtained using such a scanner is not lower than the average (along the Z axis), and high – in the directions of the X and Y axes.

Thus, based on the above, it is seen that the vast majority of mobile applications described by scientists are designed for the Android operating system [12, 13]. Only one application is offered for the iOS operating system [16].

The paper [17] presents different examples of using mobile applications during educational simulation of a design product, in managing students' remote independent work.

Scientific papers do not reflect the developments related to the direct design of shoe parts. However, similar studies have been performed in the field of clothing design [18, 19]. The paper [18] develops a prototype of a mobile application for calculating the parameters of the basic design of shoulder clothing and studies the market of mobile applications that are directly or indirectly related to the garment industry. Besides that, there is a number of papers dedicated to studies of fashion clothing market and its tendency to mobile shopping [20, 21].

In the paper [19] the mobile app for calculating the parameters of several different garments parts is presented. Both works [18, 19] provide the description of apps those might be used by professional patternmakers. Thus, the apps do not contain information on the method of drafting or its sequence.

In works [22, 23] the analysis of known methods of designing of top footwear details is performed. As a result, it has been found that computational and graphic methods of construction (copying and graphic system) are the most commonly used, and they are based on the use of conditional scanning of the block with the base lines applied to it. Baselines reflect the anatomical structure of the foot.

At the same time, the description of the method of construction of shoe parts is often an unstructured text, as in [24], and the methods themselves are not divided into separate operations, which makes it difficult for students to understand the task.

Thus, the analysis of literature sources indicates the need for additional research and systematization of known data for the introduction of mobile technologies in the process of designing shoe constructions as well as in apparel design.

<u>The purpose and objectives of the study</u>

The aim of the study is to develop a mobile application to support the process of shoe design using computational and graphic methods of construction which can be used both in production and in the learning process.

To achieve this goal, the following tasks were set:

- to analyze the market of existing mobile applications for use in the design and footwear manufacture (prototype search);
- to generate initial data for application development;
- to substantiate theoretically the principle of operation of the application;
- to develop a prototype of a mobile application;
- to perform testing and evaluation of the developed application.

3 MATERIALS AND METHODS

3.1 Analysis of the market of mobile applications in the footwear industry

For the general statistical set of mobile applications used in the manufacture and operation of footwear, we have accepted mobile applications, which are placed on the platforms of Google Play and App Store. The sample is formed by search results on the relevant platforms of mobile applications by keywords: shoes, shoes patterns, drafting shoes, smart shoes, etc. The total number of considered applications is 260 units: 201 Android applications from Google Play and 59 iOS from the App Store. It has been found out that the set of mobile applications developed for the Android operating system significantly outperforms mobile applications for iOS (77% vs. 23%).

According to the results of a review of mobile applications developed for the Android operating system and posted on Google Play, it has been found out that they can all be divided into 16 categories depending on the function they perform Figure 1. The most numerous are groups of applications that are actually catalogs of ideas for creating your own shoe models and applications of online shoe stores (32.02% each). For the purposes of designing and manufacturing shoes, you can use applications that scan the foot to determine its size (2.96%), shoe patterns (2.46%), design the appearance of shoes (2.46%). Other categories relate to the purchase or operation of footwear, as well as hobbies.

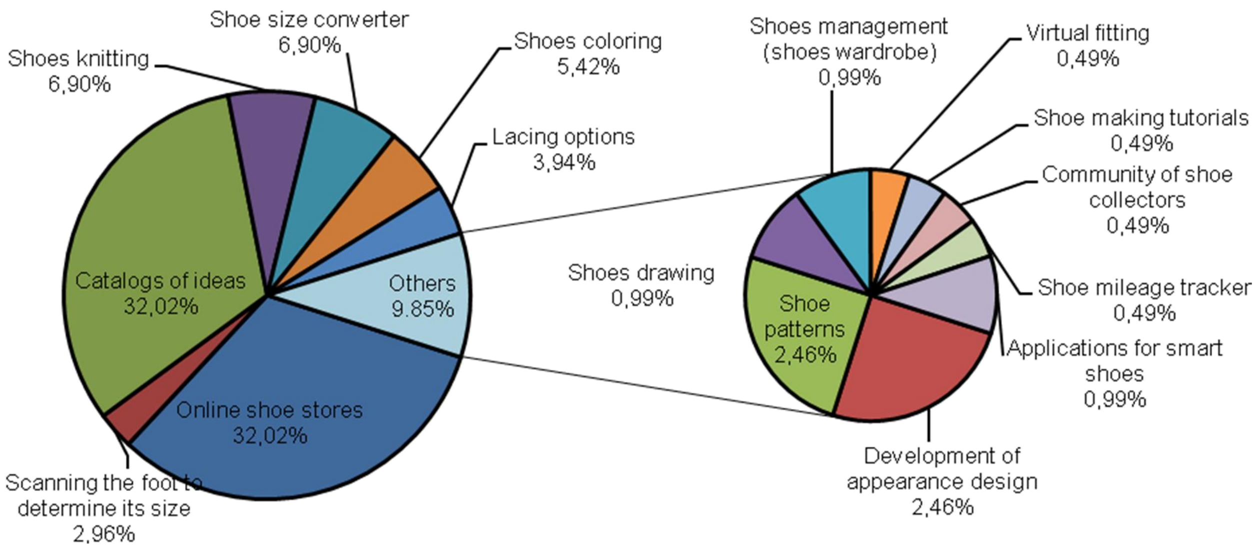

Figure 1 The ratio of the number of mobile applications of different groups used in the footwear industry (Android)

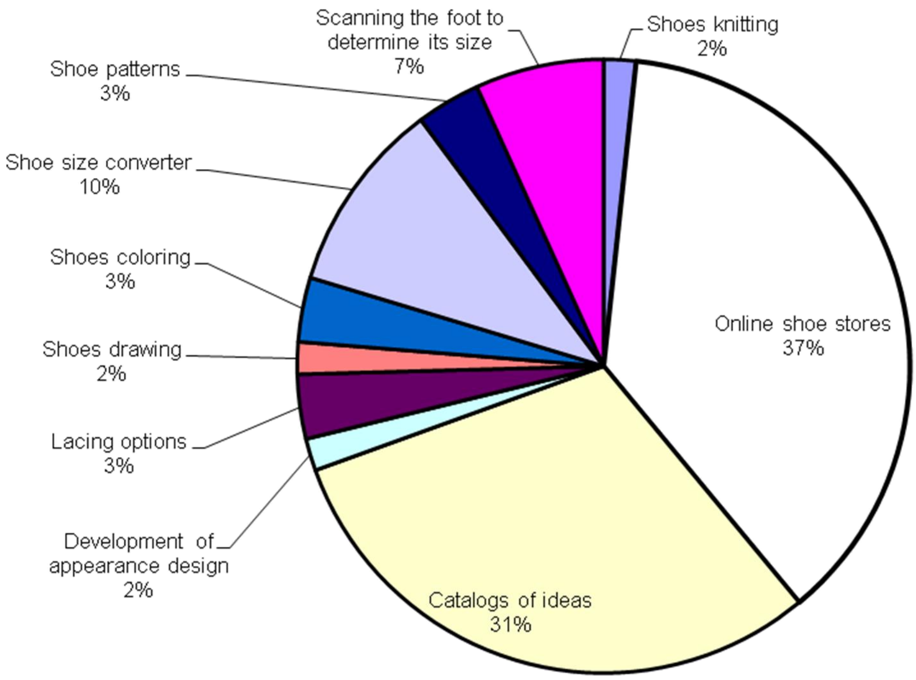

Figure 2 The ratio of the number of mobile applications of different groups used in the footwear industry (iOS)

Applications developed for iOS are represented by 10 categories (Figure 2). As in the case of Android, the largest categories are online shoe stores (37%) and catalogs of ideas (31%). From those categories which can be used for production or design of footwear, it is possible to allocate groups of footwear patterns (3%) and scanning the foot to determine its size (7%).

Figure 3 shows that the absolute value of each of the categories of mobile applications for Android exceeds the value of the corresponding category of applications for iOS.

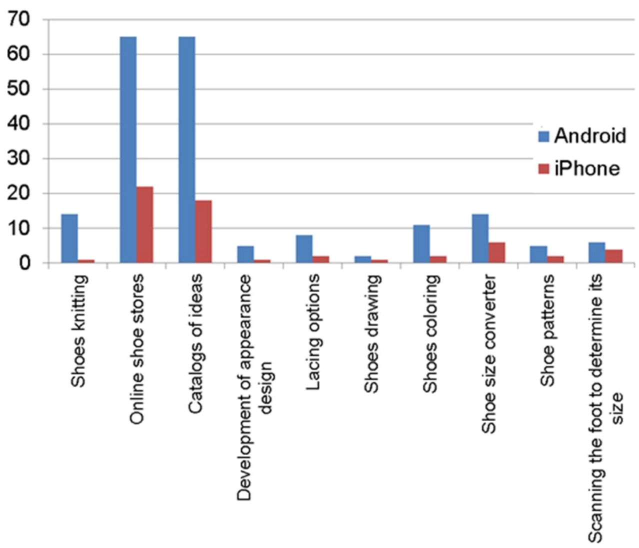

Figure 3 The ratio of the same categories of mobile applications designed for different operating systems

At the same time, the total value of the largest categories – online shoe stores and catalogs of ideas at times exceeds the values of other categories (Figure 4), and individual categories – even dozens of times.

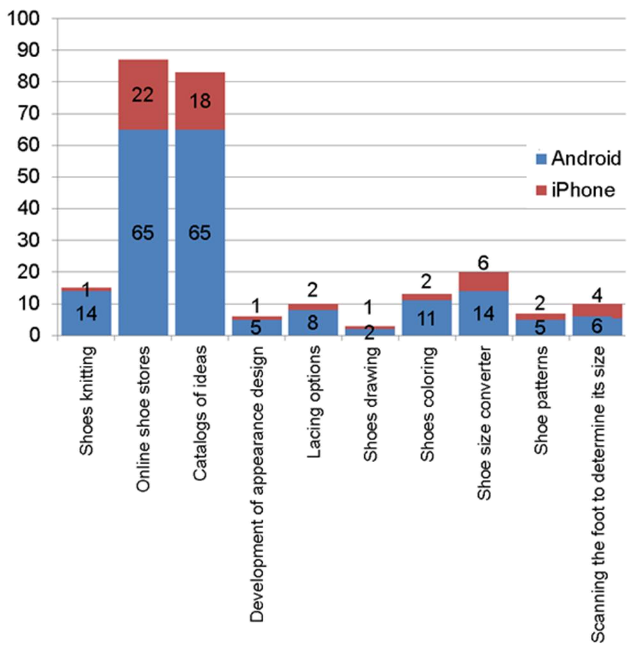

Figure 4 The ratio of categories of mobile applications

As revealed in the analysis of literature sources and publications, the greatest interest among the existing mobile applications on the market are applications-scanners feet, the main purpose of which is to determine the specific shape of the foot and its size, followed by selection of shoes in online stores. In addition to the applications described in the previously discussed scientific articles [14-16], the following applications are known on the market: Shoe-buddy (China) (SHOEGenius™, FOOTGenius™), ATLAS (Germany) (ATLAS Fußvermessungs), FootFact (Germany), FISCHER Scan -Fit (Austria), OrtoPie Scan (Peru).

3.2 The market of mobile applications in the apparel industry

The market of mobile applications in the apparel industry is fully described in [18, 19]. It was determined that there are 14 types of the mobile applications that are used in garment industry. All of them are considered to be very useful for the studying purposes. The main contribution to all of the categories large and small alike is made through the Android operating system. It was found out that “Pattern calculators” group is one of the smallest categories. It is represented by four applications (Chalk, JSK Patrones, Circle Skirt Calculator, Solo Patrones App) that were found in the search results and two applications those were developed and described in [18, 19].

Step by step sequence of pattern drafting is performed in the app “JSK Patrones”. However, it provides ability to draft only the simplest construction design of garment. Thus, it was confirmed that there are no enough tools on the mobile apps market to provide clothing designers with ability to calculate the parameters of the clothing blocks and to learn the pattern drafting technique simultaneously.

4 DEVELOPMENT OF A PROTOTYPE OF A MOBILE APPLICATION

4.1 Formation of initial data for application development

The description of the technique is usually accompanied by several drawings showing several stages of construction, and sometimes the entire construction. Since the details of the shoes are relatively small, and in order to comply with the drawing rules of drawings’ design, all symbols and lines must be of a certain size, the resulting drawing is quite cluttered, difficult to read even by a specialist. It is almost impossible to read such illustrations for a person who is just beginning his career in the profession.

Therefore, for use of the mobile application of calculation of details’ design of footwear in the conditions of distance learning, it is expedient to illustrate all stages of design construction.

This mechanism is practically analogous to the process of modular synthesis of clothing designs developed in [25, 26]. According to the author's definition [25, 26], a structural module (SM) is a unified graphic element that has certain dimensional and parametric characteristics and provides functional and structural compatibility of graphic primitives in the design of the part.

Representation of each graphic element by generation from graphic segments provides ordering of sequence of graphic procedures in computer graphics. This system of structural modules is open and involves the addition of subsystems of the graphical representation of the respective modules in the form of layered construction of a complex drawing.

To achieve this task, the descriptive nature of the presentation of the method of design construction of the upper parts of the shoe is presented in the form of a system of structural modules of the upper parts (in the form of Table 1). The whole technique is divided into 58 elementary operations and corresponding structural modules. Each operation is characterized by a tuple of attributes: number in order; segment name (points, sections); calculation or specific value of the segment; direction of deposition (construction); features of graphic construction.

Table 1 System of structural modules of shoe upper parts

KM	Segment (point)	Size (formula)	Direction	Features of construction
1	2	3	4	5
1	OX	-	→	Horizontal with t. O
2	OY	-	↑	Vertical with t. O
3	$OB_к$	-	↑	Heel lift height
4	$B_кP$	$062L_{csp}$	→	From point Vk on the axis OX notch point P
5	p. M_1	-	-	p. M1 is the most protruding point of the sock part of the template. The lower heel angle of the conditional scan pattern of the pad (CSP) is combined with the point Vk, and the most protruding point of the lower contour of the template with the point P
6	p. M_2	-	-	Holding the template in p. Vk, lower the inner contour of the CSP to point P
7	M_1M_3	$0.5M_1M_2$	↓	The template is placed with the toe part in the M3 volume, and the heel part in the Vk point, and the lower contour of the CSP to the p. P is copied.

KM	Segment (point)	Size (formula)	Direction	Features of construction
8	$B_{к}B_{к}'$	5 mm	↑	With respect to p. P CSP is rotated so that the lower point of the heel contour coincides with p. Vk ′
9	O_1X_1	-	→	Through p. Vk 'and P
10	$O_1У_1$	-	⊥ O_1X_1	Tangent to the most convex point of the heel of the CSP
11	O_1I	0.23 L_{csp}	→ on O_1X_1	
12	O_1II	0.41 L_{csp}	→ on O_1X_1	
13	O_1III	0.48 L_{csp}	→ on O_1X_1	Perpendiculars to the O_1X_1 axis
14	O_1IV	0.68 L_{csp}	→ on O_1X_1	
15	O_1V	0.78 L_{csp}	→ on O_1X_1	
16	$B'_{к}B_{п}$	$0.15N_{м}+25.15$		$N_{м}$ - shoe size in the metric numbering system
17	$B'_{к}B_{з}$	$0.15N_{м}+12.0$		
18	K_1K_2	-	-	Intersection of the V baseline with the contour of the template
19	K_1K	$0.5K_1K_2$	↓ on K_1K_2	p. Vp and p. Vz are combined with p. K
20	p. M	-	-	Intersection of baseline IV with the upper contour of the CSP
21	p. L	-	-	Intersection of baseline III with the lower contour of the CSP
22	Mb	0.35 ML	↓ on ML	-
23	Mb'	0.5 ML	↓ on ML	bb' - the maximum allowable distance of the vamp line from the sock part of the CSP
24	$B_{п}$1	3 mm	→ on $B_{п}K$	-
25	p. 2	3 mm	← ⊥ CSP	At the point of greatest convexity of the heel of the CSP
26	$B'_{к}$3	2.5 mm	←	Points 1, 2, 3 are connected by a smooth curve, which is continued down relative to the CSP by the amount of allowance for the tightening strip
27	p. 4	-	-	Intersection of baseline I with $B_{п}K$
28	4-4'	6 mm	↓	-
29	p. 5	-	-	Intersection 1-4 'with baseline II
30	5-6	8 mm	← on 5-1	-
31	6-7	-	At an angle of 107° to 6-1	To the intersection with the upper contour of the CSP
32	7-8	1.5 mm	↓ on 6-7	-
33	8-9	50 mm	|| the upper contour of the CSP	-
34	p. C	-	-	The position of the deepening of the union, focusing on t and b and b '
35	p. H	-	-	The most convex point of the sock part of the CSP
36	HH_1	4 mm	↓	-
37	H_1H_2 - the line of inflection of the vamp	-	-	A right triangle is imposed so that one of its legs passes through p. H_1, the other through p. C, and the top of a right angle was located on the top contour of CSP (p. H_2)
38	Continuation H_1H_2	-	← → on H_1H_2	To the right of point H_1 along the contour of the sock part of the CSP by 11 mm and to the left of point H_2 to the intersection with the baseline I
39	C-10	15 м	→ || H_1H_2	-
40	10-11	9 mm	↓ on 9-10	-
41	11-11'	-	←|| $B_{п}K$	H_1H_2 - the bend line of the vamp
42	11'-12	2 mm	← on 11-11'	-
43	L-13	0.5(O_1III-O_1II)	← on the lower contour CSP	Half the distance along the lower contour of the CSP between the base lines II and III. Point 13 is connected with point 12
44	angle 8-6-1	45 mm	-	Rounding radius
45	angle 6-8-9	9 mm	-	Rounding radius
46	angle 8-9-11	22 mm	-	Rounding radius
47	angle 11-12-13	20 mm	-	Rounding radius
48	14-15	9 mm	←	-
49	15-16	1/2 the width of the tongue at the top	↓ on ⊥ H_1H_2	point 16 is connected with point C
50	angle 15-16-C	10 mm	-	Rounding radius
51	1-18	4 mm	-	Allowances for bending of the upper and front edges
52	1-17	13 mm	← angle 18-1-17= angle 18-1-4'	-
53	1-19	8 mm	↓	-
54	Thread fastening	2 mm	|| 11-12	Above point C
55	The line of the tongue cut	-	⊥ vamp bending lines	So that it was closed by the front edge of the ankle boots
56	Seam allowances	5-8 mm	-	Depending on the number of stitches
57	Tightening strap	-	-	Template curve with allowances
58	The contour of the vamp wing	At a distance of 8 mm	|| contour of the ankle boot	-

Each of the operations is illustrated by a separate drawing. Black color depicts graphic elements of the drawing, made during elementary operations, the sequence numbers of which precede the current one. Red shows graphical elements that were built during the current elementary operation. Some elementary operations are illustrated by two drawings (operations 8 and 37) to facilitate the perception of graphical information (Table 2).

The sequence of operations of designing the garment parts (by drafting method called RDM) is prepared in the similar way. It was illustrated separately for each garment style and part (Tables 3 and 4).

Table 2 Modular synthesis of the design of shoe uppers (selected fragments)

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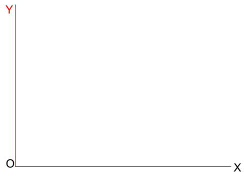
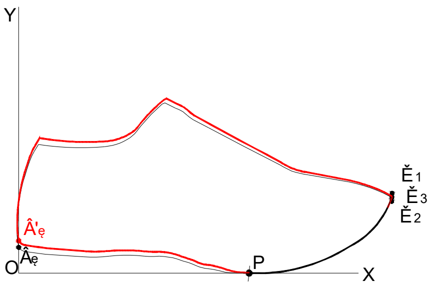
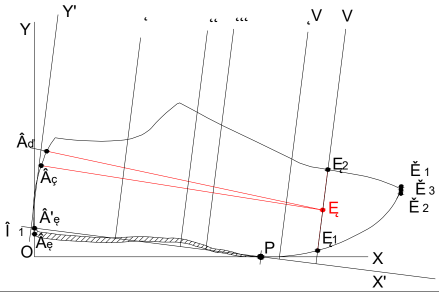
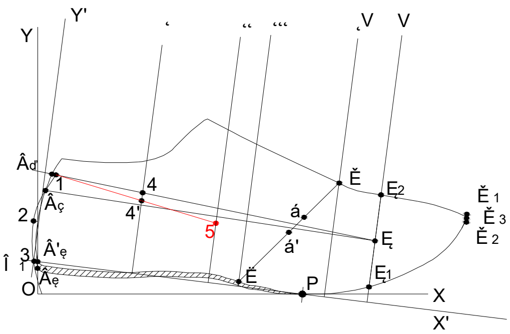
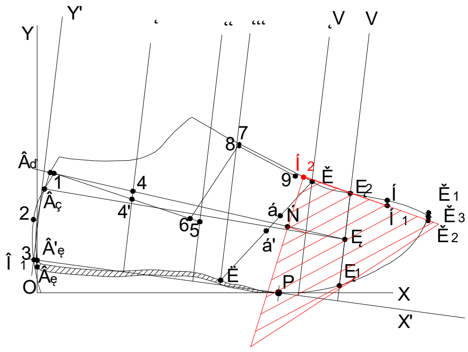
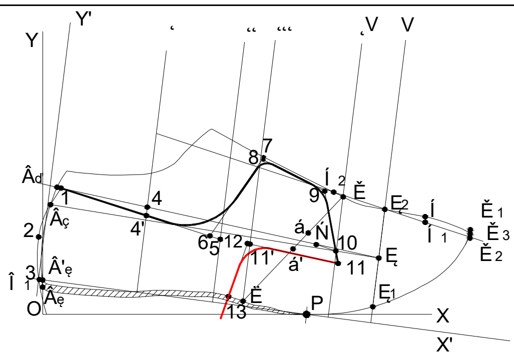
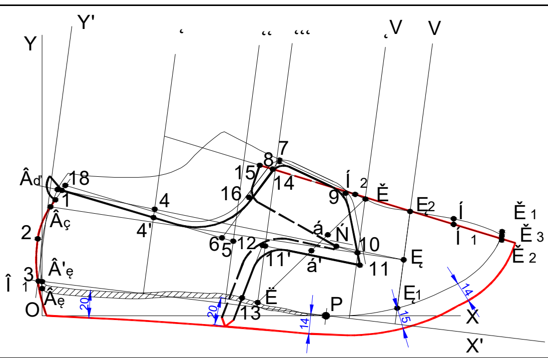
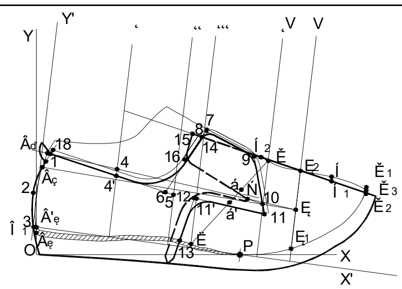
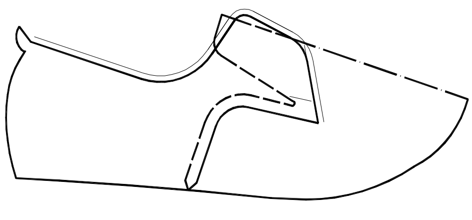
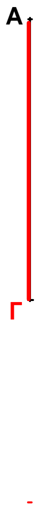
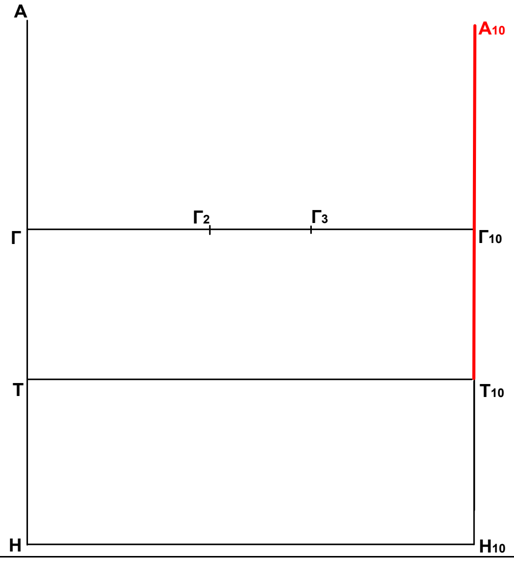
1		2	
8		19	
29		37	
47		57	
58		-	

Table 3 Modular synthesis of the basic design of a garment (selected fragments)

<table>
<tr><th>KM</th><th>Graphic illustration</th><th>KM</th><th>Graphic illustration</th></tr>
<tr><td>1</td><td>
</td><td>8</td><td>
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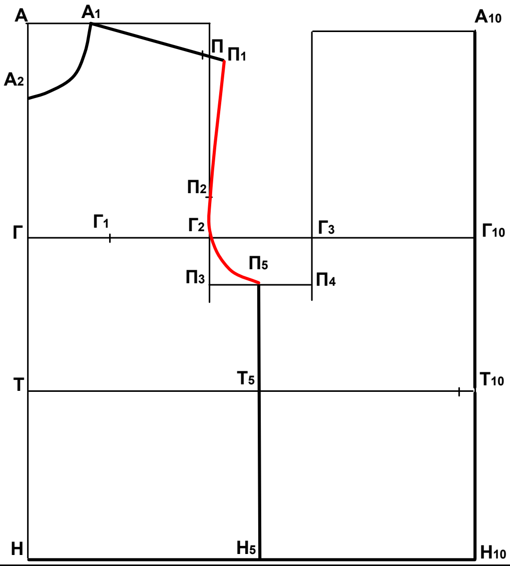
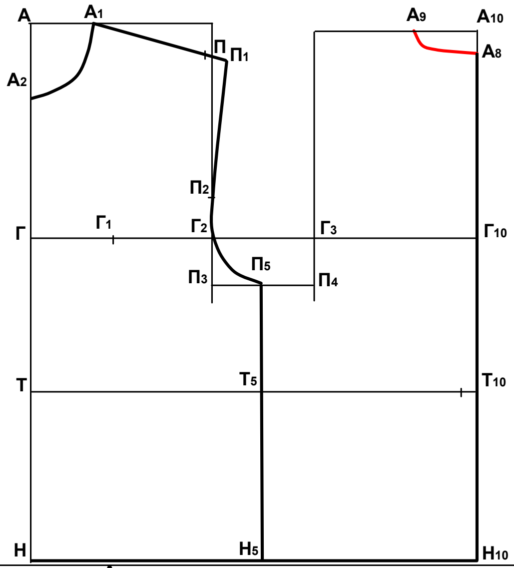
<tr><td>20</td><td>
</td><td>23</td><td>
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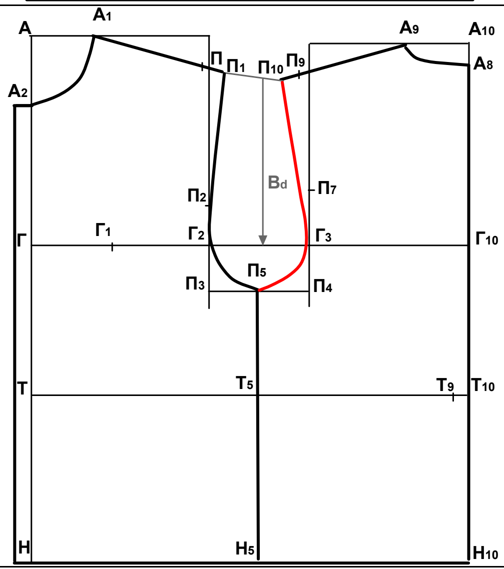
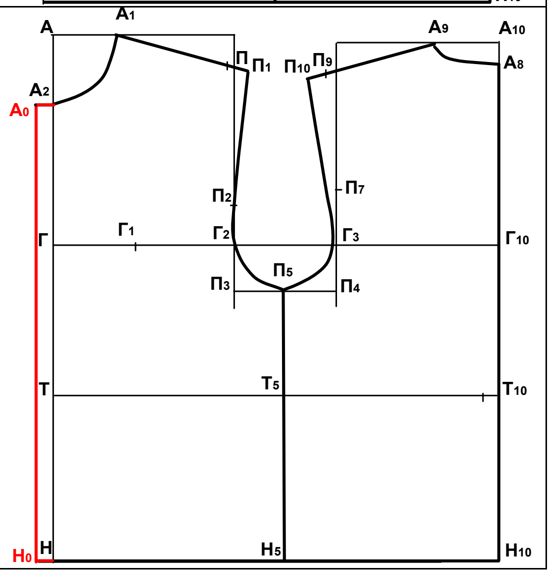
<tr><td>28</td><td>
</td><td>29</td><td>
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Table 4 Modular synthesis of the basic design of sleeve

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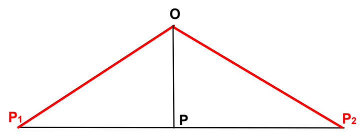
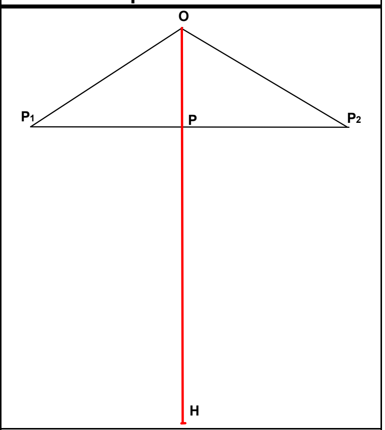
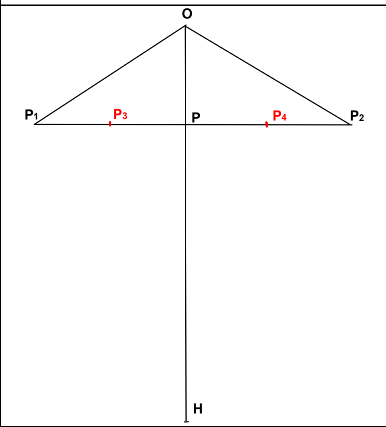
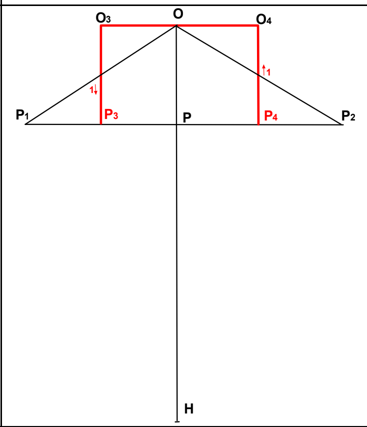
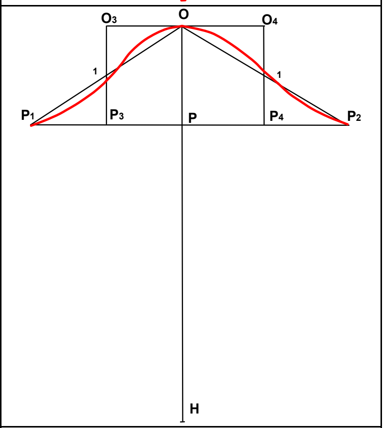
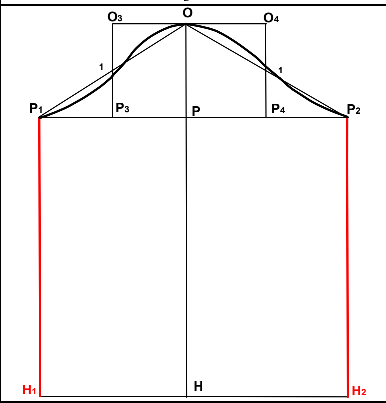
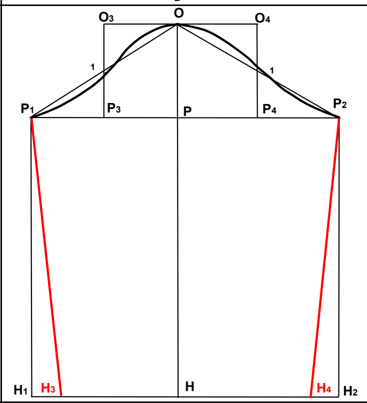
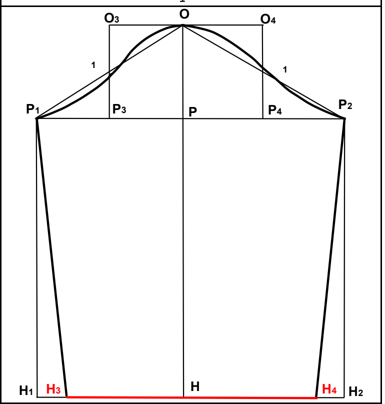
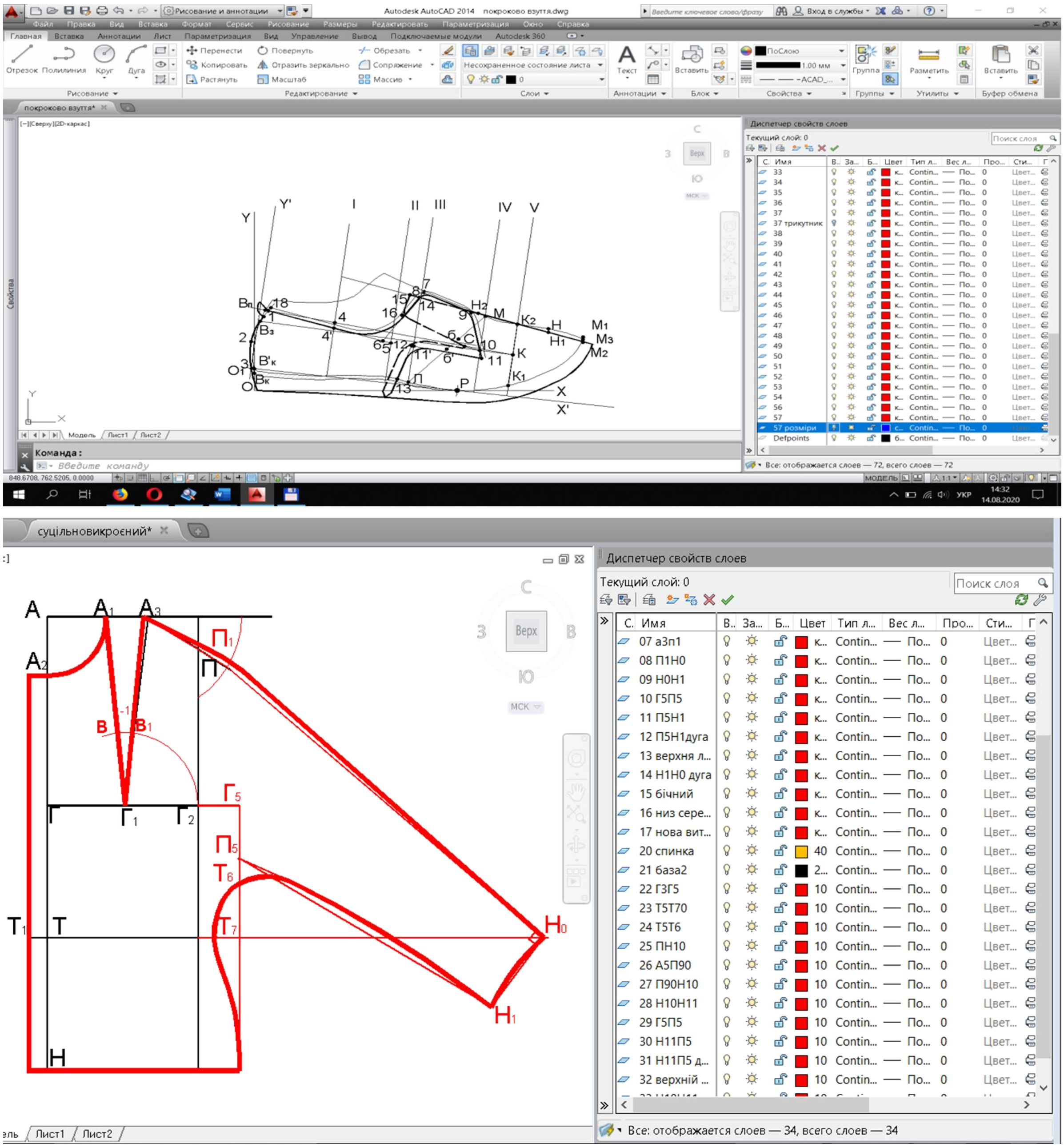
1		2		3	
4		5		6	
7		8		9	

Implementation of step-by-step layering of structural modules on the principle of modular synthesis is performed using the mechanism of switching on and off layers in the field of the graphic editor AutoCAD (USA) Figure 5. The names of the layers correspond to the numbers of elementary operations (structural modules).

Thus, the necessary array of graphic and textual information for the development of the structure of the mobile applications is formed. The use of approaches to modular synthesis of structures allows us to provide the principle of step-by-step construction of shoe and garment parts.



a)

b)

Figure 5 The mechanism of layering in the AutoCAD field for the formation of a modular synthesis of the drawing of the pattern design in the development of illustrations of the mobile application: a) shoes design; b) garment pattern design

4.2 Theoretical background of the principle of the applications operation

For the application to work, the concepts of "elementary operation" and "constructive module" are replaced by term "step", a more understandable one for ordinary users. This term defines the names of the applications being developed. In its essence, each step is an elementary operation of calculation and construction of the design of the details, represented by a graphic image of the structural module and a textual and digital description of the actions performed.

The number of graphic illustrations determines the number of Vertical Arrangement blocks selected as the main means of creating individual construction steps in a mobile application for the Android operating system developed in the MIT App Inventor (USA).

"SHOES Step-by-Step"

Each block of Vertical Arrangement contains the name of the elementary operation, a graphical representation of the structural module, the corresponding textual explanation (columns 3-4 of Table 1), as well as the calculation of the segment size (or a given default value) in mm.

The calculation is performed in steps 4, 7, 11-15, 16-17, 19, 22, 23, 43, 49 (Table 1). The content of the steps determines the necessary initial data that must be entered by the student before the calculation, as well as those data that must be entered during the construction.

The initial data include: Lcsp – the length of the conditional scan of the pad (CSP), mm; Nm – shoe size in the metric numbering system. The number of output values determines the number of blocks for entering text information (TextBox): two blocks that must precede the direct command of the calculation / start of construction. The information from these blocks will be used in steps 4, 7, 11 17.

Information to be entered during construction: the values of the segments K1K2 and ML, the distance along the lower contour of the CSP between the base lines II and III, the width of the tongue at the top.

These distances are measured directly on the drawing after performing the previous basic operations. Thus, in steps 19, 22, 43 and 49 you need to place additional blocks of text input.

“RDMK Step-by-Step”

Similar structure of Vertical Arrangement blocks was used to construct the mobile app “RDMK Step-by-Step”. The name RDMK corresponds to the name of the drafting method (that is RDM).

There are 16 steps for the construction of parts of top wear design. The initial data include 14 body measurements for the bodice, 6 body measurements for the sleeve, 4 amounts of eases for the bodice, and 2 amounts of eases for the sleeve (measured in cm).

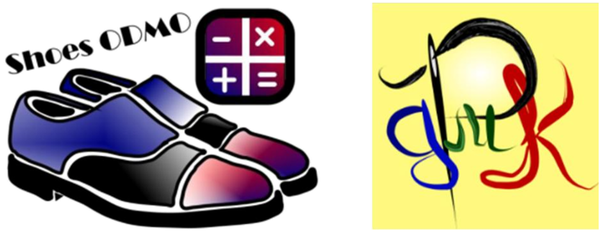
Information to be entered during construction: the values of the segments G1G2 (for the bodice) and L1L3 (for the sleeve). These distances are measured directly on the drawing after performing the previous basic operations (exactly as it was for the shoes design). Thus, additional blocks of text input are placed in steps 7 of sleeve construction and step 1 of the bodice construction.

The application gives users the option of completing the text fields by a shorthand method on the basis of what has been typed before. Otherwise, the fields will be autocompleted by zeros.

4.3 Software implementation of the mobile applications

An application for calculating the original design of shoes according to the method described in [18, 22]. Two application languages are used: Ukrainian and Russian. The applications (Figure 6) are intended for the use:

- by teachers and students of higher education institutions (HEIs) (fields of study: "Light industry technologies"; "Vocational education. Technology of light industry products"; "Fashion industry");
- by the representatives of shoe companies (“SHOES Step-by-Step”) or clothing designers / patternmakers (“RDMK Step-by-Step”);
- by students and teachers of colleges, technical schools of these specialties.



a) b)

Figure 6 Developed applications’ icons: a) “SHOES Step-by-Step”; b) “RDMK Step-by-Step”

To work with the application (“SHOES Step-by-Step”, the user enters the source data and presses the button "START CONSTRUCTION" (Figure 7a). The user is provided with an image of the construction drawing, a sequence of formulas, the names of the segments and their calculated values. Dialog boxes of the developed mobile application are presented in Figure 7. A significant number of stages (steps) of construction led to the need for the operator to go from the main page to any of the steps Figure 7b. In Figures 7c - 7e the steps of construction with a different set of attributes are shown. In Figures 7c - 7d the presence of the unit for calculating the value of the segment is shown. In Figure 7e calculation unit is missing. The block of explanations of features of graphic construction is shown in Figure 7c. In Figure 7g block of explanations is missing. In addition, in Figure 7c block for entering text information is presented.

If the user does not enter the source data, the input fields will be automatically filled with zeros. The developed application “SHOES Step-by-Step” is available for testing at:

https://play.google.com/store/apps/details?id=appinventor.ai_zbirvukladach.Shoes_copy&hl=en.

To work with the application (“RDMK Step-by-Step”), the user chooses style of the garment to be designed. The app allows calculating the parameters of garments with set-in sleeves and owlman style garment. The construction of owlman style may be performed only after completing computing the parameters of the basic bodice design (set-in sleeve).

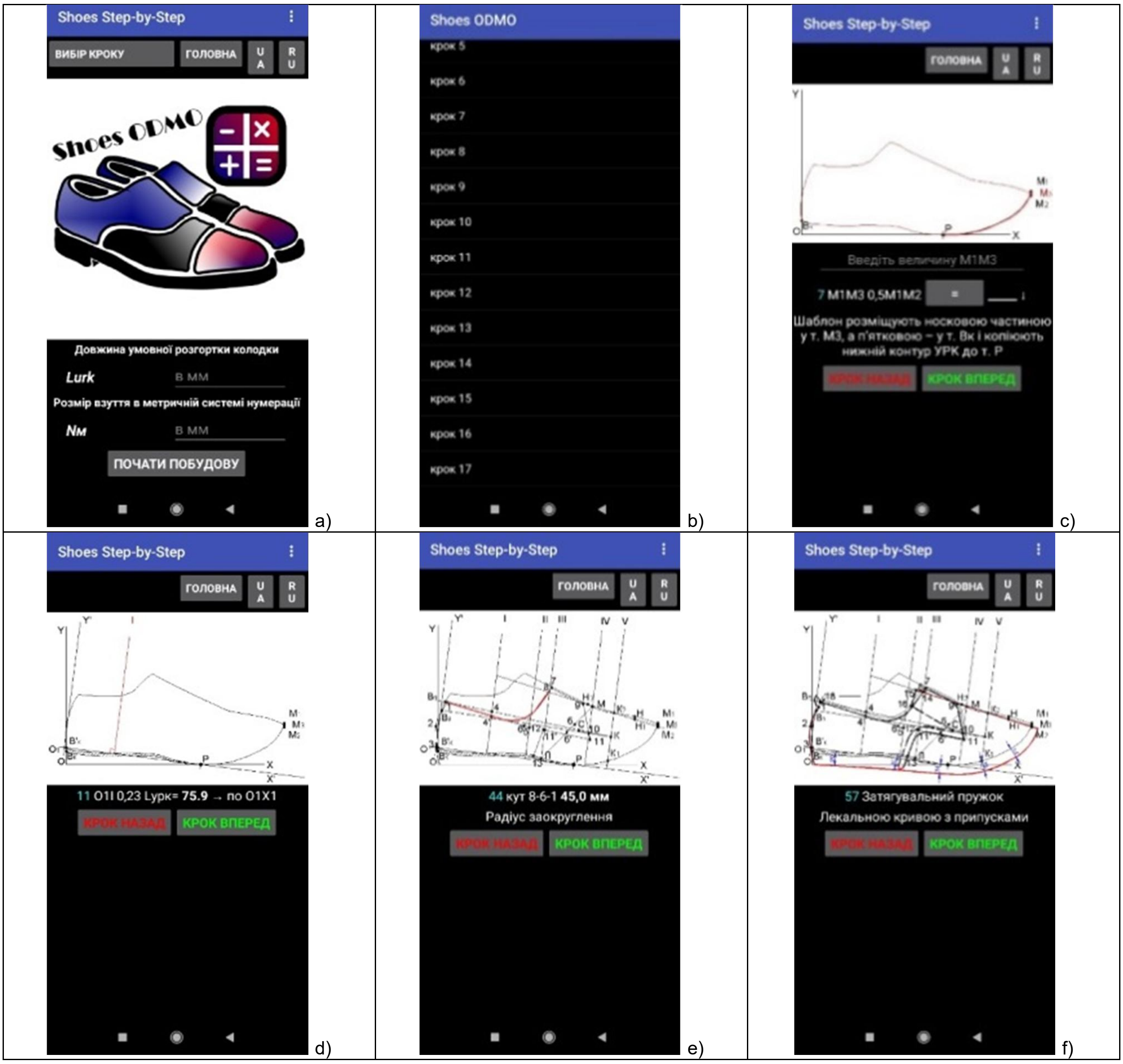


Figure 7 Dialog boxes for working with a mobile application "SHOES Step-by-Step": a) main page; b) choice of construction step; c) step 7; d) step 11; e) step 44; f) step 57

After that, the user chooses "BODICE" or "SLEEVE" button (Figure 8a) and enters the source data and presses the button "START CONSTRUCTION" (Figure 8b). The user is provided with an image of the construction drawing, a sequence of formulas, the names of the segments and their calculated values (Figure 8c). Dialog boxes of the developed mobile application are presented in Figure 8. A number of steps of construction led to the need for the operator to go from the main page to any of the steps in the similar way as it was shown for the application "SHOES Step-by-Step".

The developed application "RDMK step-by-step" is available for testing at:
https://play.google.com/store/apps/details?id=appinventor.ai_zbirvukladach.RDMK.

4.4 Testing and evaluation of the developed application

The semantic differential method described in [23] was used to evaluate the developed applications. At the first stage of using this method, pairs of words with opposite meanings are formed, which form a semantic differential. Each pair of Kansei words is a bipolar pair for a separate attribute of the developed application: speed, accuracy, complexity, convenience, relevance (needs). The scales of the semantic differential for each attribute of the mobile application were represented as bipolar pairs expressed by adjectives or adverbs. The scales are presented in the form of horizontal rulers in the questionnaire.

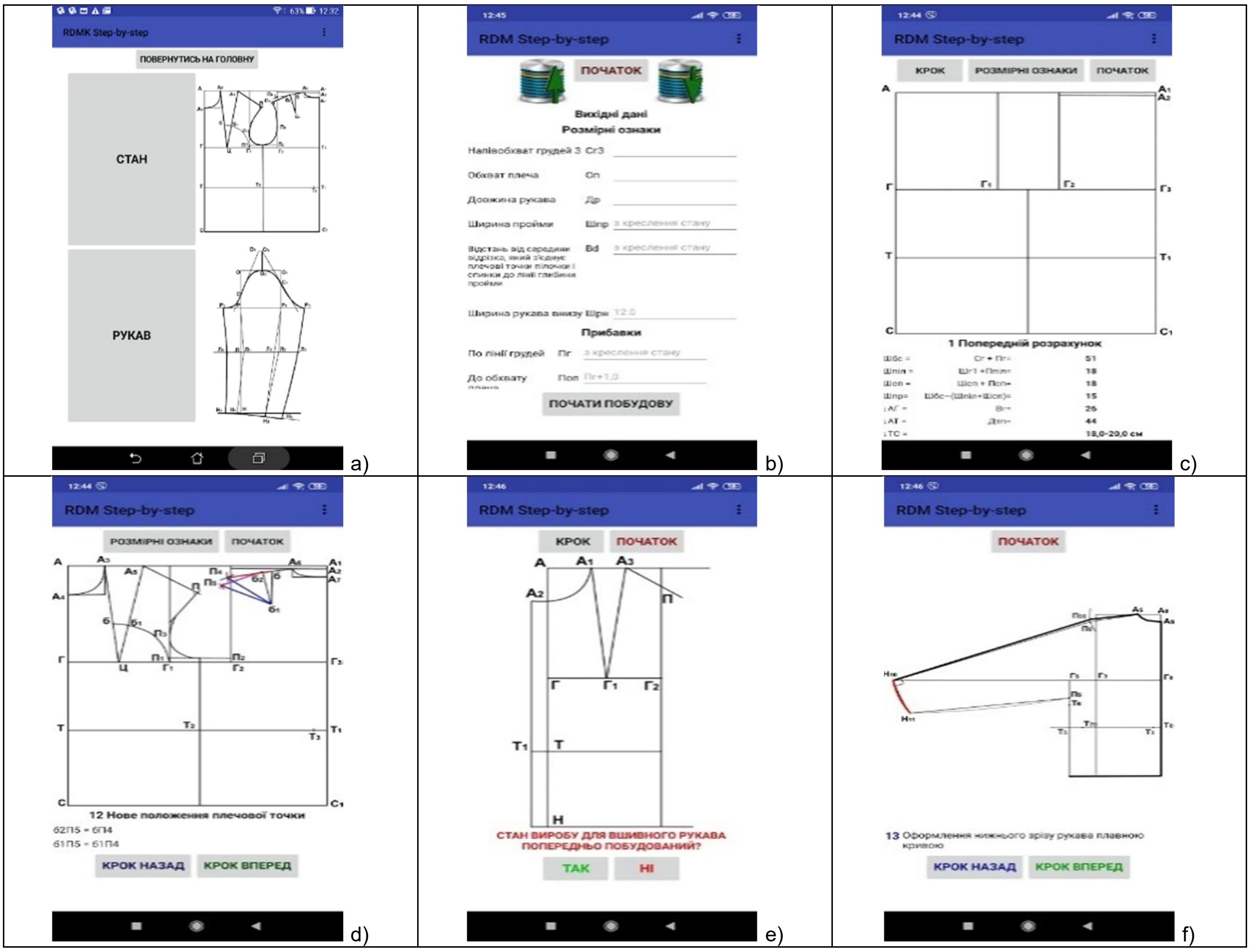


Figure 8: Dialog boxes for working with a mobile application "RDMK Step-by-Step": a) main page; b) input data; c) step 1 12 (basic design, set-in sleeve); d) step 12 (basic design, set-in sleeve); e) step 1 (owlman style); f) step 13 (owlman style)

Each scale has seven gradations of values, which are expressed in numerical form (-3, -2, -1, 0, +1, +2, +3) Figure 9.

	-3	-2	-1	0	1	2	3	
slow								quick
complicate								simply
inaccurate								accurate
user-unfriendly interface								user-friendly interface
unnecessary								necessary

Figure 9 Semantic differential scales used for the survey

For ease of representation of Kansei words, all bipolar pairs were encoded with the first letters of words, which is common practice: SQ (Slow-Quick); CS (Complicated-Simple); AI (Accurate-Inaccurate); FU (User-Friendly interface – User-Unfriendly interface); NU (Necessary-Unnecessary).

At the next stage of the study, the applications were tested by experts and evaluated using a developed questionnaire. The first expert group consisted of 10 representatives of the footwear industry (students, teachers, representatives of the real sector of the economy) and 10 representatives of related specialties. The first group evaluated the app "SHOES Step-by-Step". The second one consisted of 52 students, and 33 teachers, clothing designers, and patternmakers. The second group evaluated the app "RDMK Step-by-Step".

As a result of the surveys, psychographic profiles of the developed mobile applications were obtained (Figures 10a-c). The profiles display the average values of the evaluation coefficients for each pair of Kansei words. As the coefficients correspond to the positive values of Kansei words, the results of the survey indicate that the experts approved the mobile application "SHOES Step-by-Step".

As it can be seen from Figure 10 experts working directly in the field of footwear production rated the application lower than specialists in related fields Figures 10a-b. This is due to the fact that experts pay considerable attention to the quality of the method of designing shoe parts, rather than the characteristics of the mobile application.

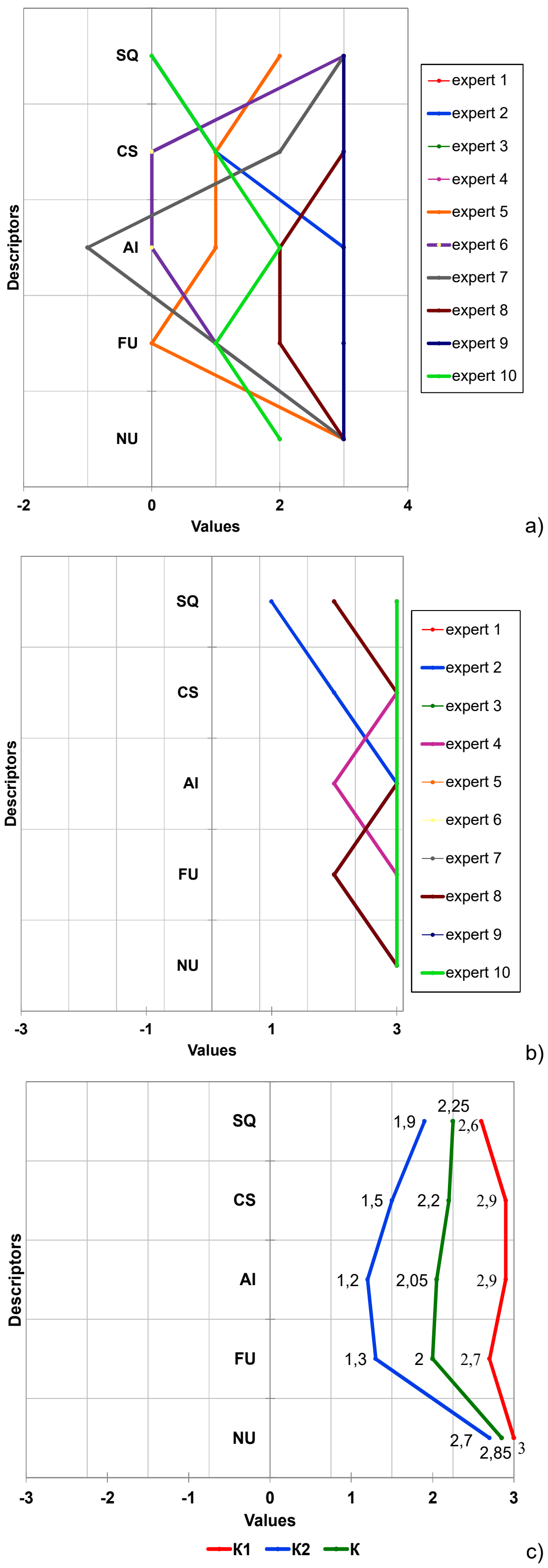


Figure 10 Psychographic profiles of the mobile application "SHOES Step-by-Step": a) expert group of 10 representatives of the footwear industry (students, teachers, representatives of the real sector of the economy) (group K1); b) expert group of 10 representatives of related specialties (group K2); c) the average values of the evaluation coefficients of the two expert groups (K)

At the same time, representatives of related specialties express their opinion more from the standpoint of beginners who assess the quality of the software product itself, through which training in shoe design takes place. However, a general tendency to a positive assessment persists in both groups Figure 10c.

As for the assessment of the mobile app "RDMK Step-by-Step", the results of it are shown in the Figure 11.

As one can see from the Figure 11, the application is assessed mostly with marks related to positive meaning of Kansei Words (Figure 9). The average values of the evaluation coefficients of the two expert groups form psychographic profiles that have clearly identical form though experts of group K2 showed much more appreciation of the app.

5 DISCUSSION OF TEST RESULTS OF THE DEVELOPED MOBILE APPLICATIONS

5.1 "SHOES Step-by-Step"

The positive assessment of the developed application "SHOES Step-by-Step" (Figure 10) is confirmed by the opinion of users from among the specialists of the footwear industry. The results of the survey showed that 90% of respondents were in favor of the use of mobile technologies in the process of calculating the shoes details. At the same time, 95% of experts preferred the tabular form of presentation of the method of parts construction (Table 1).

The structure of the proposed method of calculation and construction of shoe parts is radically different from the solutions known in the field [22–24], as none of them uses mobile technology. A known solution from a related field, namely a mobile application for calculating the parameters of the basic design of shoulder clothing [18, 19], is not accompanied by step-by-step illustrations and explanations.

The results of this work can be extended to all methods of designing shoe parts, which are based on calculation and graphic methods of construction. However, currently the application is used only for one specific technique. The calculation is performed only in millimeters. To use the application, the user must have at least a superficial knowledge of specialized terminology: conditional scan of the pad, the metric numbering system of shoe sizes, the names of the details of the shoe upper, and so on.

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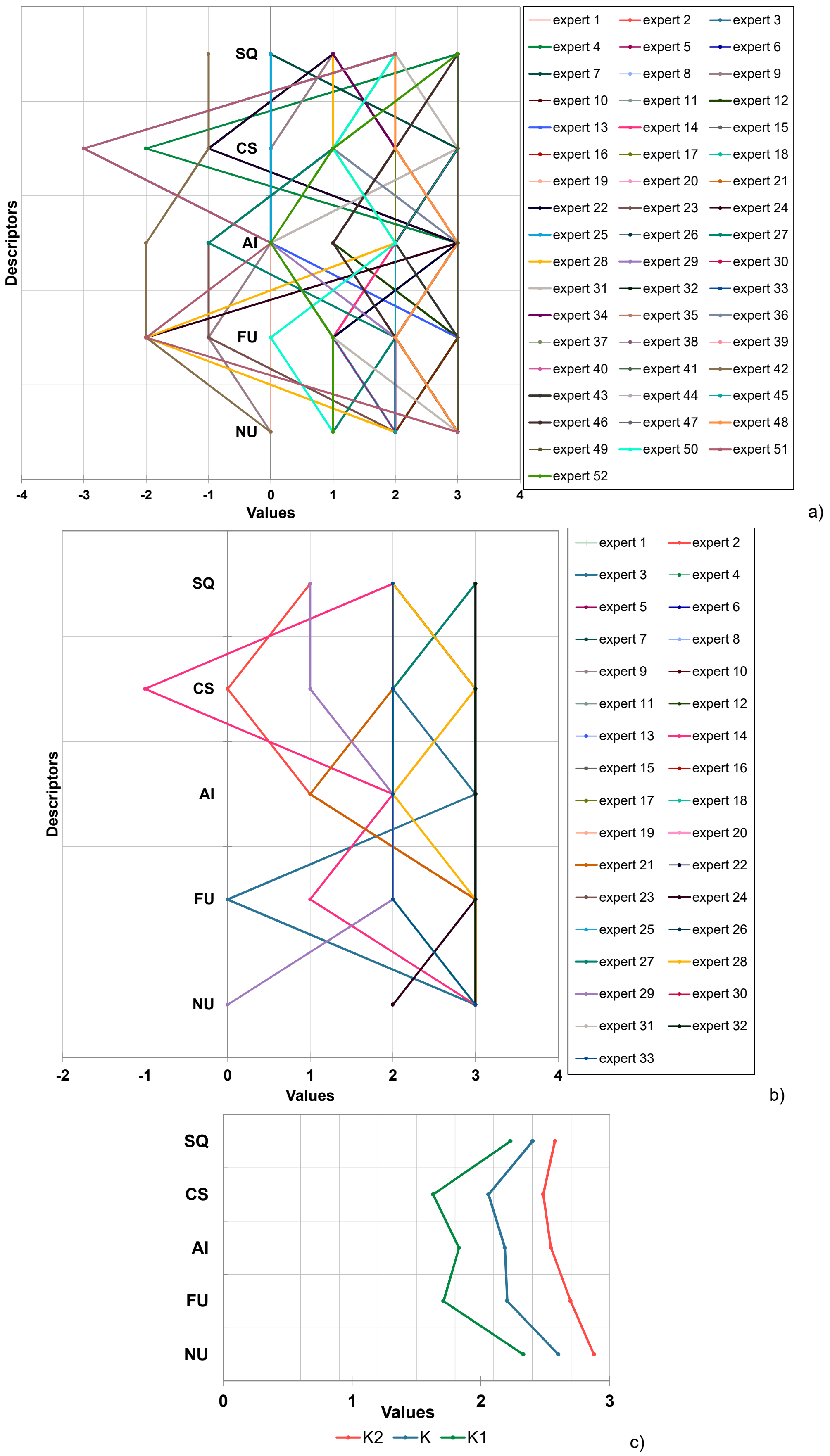

Figure 11 Psychographic profiles of the mobile application "RDMK Step-by-Step": a) expert group of 52 students (group K1); b) expert group of 33 teachers (group K2); c) the average values of the evaluation coefficients of the two expert groups (K)

This solution of the application provides adequate and accurate construction of the structure only if the input data is entered correctly. The calculation blocks do not contain operators for checking the entered data and the obtained results. Adding such an operator would ensure the accuracy of the constructed structure, and not just error-free reproduction of the sequence of actions.

After successful testing of the application in higher educational institutions, it is advisable to ensure its operation in English. In addition, it is necessary to add the ability to perform calculations of the parameters of the details of the bottom of the shoe, as well as the details of the lining, back, toe, etc. Such functions are easily implemented using the above sequence of actions. The description of the modular synthesis is ensuring reproductivity of the results of study.

The development of this study is to create an algorithm not only for calculation, as in this case, but for the automated construction of patterns of shoe parts. Such an algorithm would allow the formation of files with patterns that are calculated and built to the size of the direct user of the application. The implementation of the construction mechanism should be combined with the results of 3D-scans of the foot using a specialized application to obtain accurate source data. Today, the technology is being actively developed in many works [14-16], but the results of scans still cannot be used to create a conditional scan of the pad. Their results are mainly used only to determine the size of shoes.

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6.2 "RDMK Step-by-Step"

Most of the concerns expressed for the application "SHOES Step-by-Step" are to be applied to the app "RDMK Step-by-Step". That is due to the similarity of the applications designs as well as methods of garment and shoes construction.

In addition, the automated construction of patterns using mobile applications has not been implemented yet neither in apparel design nor in footwear industry. This is due to the significant variety of sizes, shapes, models and patterns of parts. Technologies of this kind require the use of artificial intelligence and machine learning systems.

7 CONCLUSIONS

According to the results of the review of mobile applications, which are related to footwear industry and presented on the digital distribution platforms Google Play and App Store, it was found that all of them can be divided into 16 categories. The most numerous are groups of applications, which are actually catalogs of ideas and applications of online shoe stores (32.02%). It was found that the absolute value of each of the categories of mobile applications for Android exceeds the value of the corresponding category of applications for iOS. This result corresponds to the general distribution of the number of users of devices with the specified operating systems (Android – 74.25%, iOS – 25.15%). No applications for calculating the design parameters of shoe parts were found on any of the platforms.

It was confirmed that there are no enough tools on the mobile apps market to provide clothing designers with ability to calculate the parameters of the clothing blocks and to learn the pattern drafting technique simultaneously.

The necessary array of graphic and textual information for the development of the structure of the mobile applications is formed in the form of a system of structural modules of shoe uppers. Each structural module is illustrated with a separate drawing, which allows you to clearly distinguish between individual construction steps.

On the basis of the systematized initial information the means for creation of separate steps of construction in the mobile application for the Android operating system – the Vertical Arrangement block is chosen. Ensuring the principle of step-by-step construction of shoe and garments parts is achieved through the use of modular synthesis of structures.

The novelty of the current study lays in using the modular synthesis as a description of any step-by-step construction. The same description and way to construct the pattern with help of a mobile app might be used for any pattern draft technique, even for those lay beyond the apparel or footwear design.

Software implementation of the mobile applications, performed in the field of visual programming, allows the use of mobile technologies in the process of designing shoes and garments.

As a result of the evaluation of the mobile applications by the methods of Kansei Engineering, the need for the introduction of mobile technologies during the training of specialists in the footwear and apparel industries was revealed. This need is justified by the positive values of the average evaluation coefficients in the psychographic profiles: 2.25/2.60 (quick); 2.2/2.2 (simple); 2.05/2.19 (accurate); 2/2.06 (convenient); 2.85/2.4 (necessary).

The mobile applications developed during the current study are available at Google Play. Thus, the results of the study might be used in a practical way by both industries and education representatives.

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