WeaveStudio: An Object-Oriented Toolkit for Textile Pattern Colouring and Visualization

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Abstract— **Textile industry includes a large number of practices and complex technical issues that operate in a competitive global industry. Recently, researchers have shown an increased interest in textile design software solution for all designing and coloring needs. However, for massive production textile designers are facing several problems related to Color Matching, Design Export, and Customize pantone coloring. Thus, textile designers need to take into account not only the design but also manufacture and technological development and the application of the final product. In order to enhance textile designers' with an optimization tools, this paper presents the design, implementation, and evaluation details of WeaveStudio Toolkit for textile pattern coloring and visualization. A combination of quantitative and qualitative approaches was used in the data analysis. Therefore, this study makes a major contribution to research on textile pattern coloring and visualization by demonstrating a valuable toolkit on the textile design suiTable for design professionals in the textile and fashion industries, as well as in academia.**

Keywords- Textile; usability; Customize pantone coloring; fashion; textile manufacture.

I. TEXTILE DESIGN

Textile designing is a creative field that is important for a wide range of scientific and industrial processes. Textile designing is a major area of interest within the field of fashion design, carpet manufacturing and any other cloth-related field [1]. This industry includes a variety of purposes, e.g., clothing, carpets, drapes, towels, and rugs are all a products of textile design [2]. It is now well established from a variety of studies, that, textile industry is now one of the most influential sectors, in the global economy, garment industrialization has become the world's third biggest industrial industry [3][4].

Textile designers should have the ability to inspire collections, trends, and styles of fashion [5]. In this regard, different textile design software's have been developed in order to making the garment industrialization more productive. Most of these textile applications share some combinations of functions such as, setup any number of style templates. The design output can be linked to specific style components, such as fabrics or size specs as well as designers specified number of solutions to be saved [6].

Despite its long experiments success, the textile software has a number of problems in use. Customize pantone coloring is one of the most frequently stated problems with the current versions of textile applications, that limits the amount of designs and hinders designers creativity growth. Moreover, there is increasing concern that some textiles applications are being disadvantaged with color matching. Therefore, these major issues have been shown to be related to adverse effects the massive design export [7]. In addition, that lack of textile software usability has been highlighted in several studies [8].

There is an urgent need to address these issues in order to make the garment industrialization more productive. This paper addresses these issues and presents design, implementation, and evaluation details of WeaveStudio toolkit for textile pattern coloring and visualization. The specific objective of WeaveStudio is to shift away from traditional textiles software where designers are limited to customize pantone coloring towards a more dynamic and productive one. In fact, WeaveStudio is built on a vision to rethink of textile production and make it more accessible and enabled designers to create their own unique brand line.

The remainder of the paper is organized as follows. In Section 2 begins by laying out the theoretical dimensions of the research, and looks at how field of textiles computer-aided design software is still relatively new and extending due to technology miniaturization. The third Section is concerned with the methodology used for this study including the WeaveStudio design and requirements. Section 4 analyses the results of interviews and focus group discussions undertaken during the implementations of WeaveStudio toolkit. Finally, we summarize our findings and outline perspectives for future work.

II. RELATED WORK

The textile design process often begins with different art mediums to match concepts for the finished product design. Nowadays, most professional textile designers are using some kinds of design software created expressly for this purpose [9]. The field of textiles computer-aided design software is still relatively new and extending due to technology miniaturization [10]. We selected the following ten textile design application for our analysis due to their particular focus on the textile pattern design and color matching.

- Pointcarre Textile Software [11].
- Vetigraph [12]
- Apparel Innovator [13]
- Color Matters International Software [14]
- Coyote [15]

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- Design Suite by Bontex [16]
- DesignSew Diva [17]
- Evolution Textile Design by DigiFab Systems [18]
- Modaris 3D [19]
- SmartDesigner [20]

we analyze each system for low-level features (e.g., CAD Tools, Color Matching, Design Export , Fabric Matching , Fashion Illustrations , Pattern Grading, Pattern Layout/ Print/ Cut, Pattern, Color & Art Storage, Presentation Tools, Textile Pattern Design and) as well as high-level features (e.g., Customize pantone coloring, flexible and user friendly). A summary of the analysis results and a comparison with the WeaveStudio software are presented in Table 1.

TABLE I. SUMMARY OF THE TEXTILE SYSTEMS ANALYSIS

Functionality	System	Pointcarre	Vetigraph	Apparel Innovator	Color Matters	Coyote	Bontex	DesignSew Diva	Evolution Textile	Modaris 3D	SmartDesigner	WeaveStudio
Low-Level Features	CAD Tools	√	(√)	(√)	(√)	√	(√)	√	(√)	(√)	√	√
	Color Matching	√	(√)	√	√	√	√	√	√	√	√	√
	Design Export	√	√	√	√	√	√	√	√	-	√	√
	Fabric Matching	√	√	√	√	-	√	√	√	√	√	√
	Fashion Illustrations	√	√	√	-	√	-	√	√	√	√	√
	Pattern Grading	√	√	-	-	-	√	√	-	√	-	√
	Pattern Layout / Print / Cut	√	√	√	-	-	√	√	√	√	-	√
	Pattern, Color & Art Storage	√	√	√	-	√	√	√	√	-	√	√
	Presentation Tools	√	√	√	√	√	√	√	√	√	√	√
	Textile Pattern Design	√	√	√	(√)	√	√	√	√	√	√	√
High-Level Features	Customize pantone coloring	-	-	-	-	-	-	-	-	-	-	√
	Flexible and user friendly	(√)	(√)	-	-	-	-	(√)	(√)	-	-	√
legend		✓ Completely supported			(✓) Partly			- Not supported				

It can be seen from the data in Table 1 that, these textile applications are support the basic features of textile design, namely CAD Tools , Color Matching , Presentation Tools, Textile Pattern Design. However, only Pointcarre, Vetigraph, DesignSew Diva, and Evolution Textile Design by DigiFab Systems are providing more advanced features, such as user friendly and usable interface. This analysis has been demonstrated that the lack of Customize pantone coloring is a major cahalenge of texttile applications that, makes their usage unpractical and out of context.

III. WEAVESTUDIO DESIGN

Driven by the wish to enhance textile software with a complete package solution for all designing and coloring needs, we follow spiral model as a combination of both, iterative model, which mixed some key aspect of the waterfall model and rapid prototyping models, in an attempt to combine wide range advantages of top-down and bottom-up concepts. [23]. We analyzed the existing textile software to identifying which functionalities they have in common,

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which functionalities were most frequently used, and what are the additional functionalities that are still required as presented in the related work Section 2.

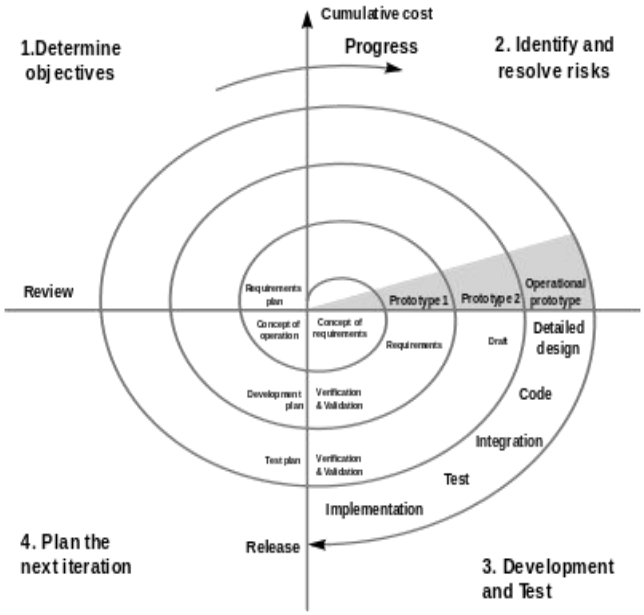

Figure 1. Spiral model [23]

A. *Survey Results*

Based on the literature review and the analysis of the existing systems, we collected design requirements regarding the main textile grading and electronic prototyping to the product design, ensuring better finish, fit and accuracy. Then, we designed a survey to collect feedback from different textile stakeholders concerning the importance of the collected requirements. The demographic profile of this survey was distinguished into academic professors and textile industrial designers as follows:

- **Academic Professors**: 23 professors who had experiences in the field of textile completed this survey. 37% from Europe, 42% from the US and 21% from Asia.
- **Textile Industrial Designers**: 42 textile industrial designers who had worked in the field of textile completed this survey. 55% from Europe, 34% from the US and 11% from Asia.

A summary of the survey analysis results are presented in Table 2. It strengthens the collected requirement to support WeaveStudio Design in order to enhance designers with an object-oriented toolkit that enable them to spend as little time as possible for entering data. From styles and trims to design sizing, sewing operations and style prototype, moreover, designers can create templates or groups of objects that can be instantly retrieved and editable if appropriate.

TABLE II. WEAVESTUDIO DESIGN REQUIREMENTS

	Design Requirements	M	SD
1	Provide CAD tools where appropriate.	3.7	0.88
2	Support color matching.	4.66	0.68
3	Provide a design export box for prototypes design.	4.23	0.56
4	Enable easier fabric matching.	4.33	0.69
5	Provide a fashion Illustrations solution.	4.68	0.89
6	Provide opportunities for pattern grading.	4.78	0.45
7	Use editing features e.g. pattern Layout / Print / Cut.	4.10	0.97
8	Framing: arrange objects Pattern, Color & Art Storage.	4.12	0.89
9	Offer a usable presentation tool.	4.41	0.82
10	Offer a textile pattern design.	4.90	0.45
11	Provide a customize pantone coloring	4.91	0.34
1. Strongly disagree … 5. Strongly agree			

B. *WeaveStudio Implementation*

WeaveStudio implementation that includes dynamic interface of linked design data, supported by an integrated object-oriented technology. In the next Sections, we will discuss the main components of the WeaveStudio user interface in some detail.

IV. WEAVESTUDIO COMPONENTS

There are several different types of layouts for repeated patterns. WeaveStudio provides a flexible workflow of product specifications modeled after the actual design.

A. *WeaveStudio Workflow*

WeaveStudio uses a common color palette to relate every aspect of style specification including graphics and textual information as shown in Figure 2. Some of the most common repeats are straight and half drop. Often, the same design is produced in many different colored versions, which are called live models as illustrated in Figure 3.

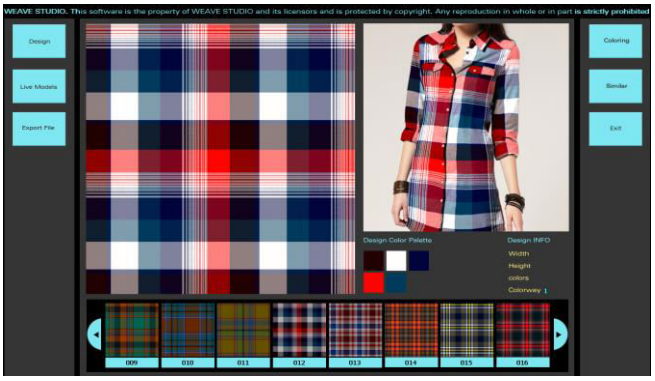

Figure 2. WeaveStudio Workflow.

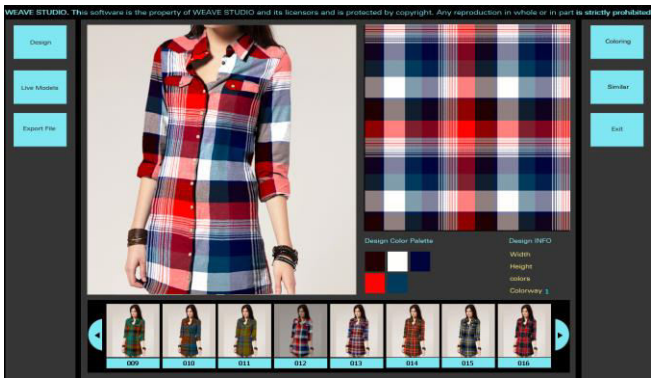

Figure 3. WeaveStudio live models.

B. *Customize pantone coloring*

Customize pantone coloring is the other method to make your textile unique. In WeaveStudio Customize pantone coloring as an expression of textile design power provide designers with a usable tool of color in constructing identity, the creation of color via contemporary technical advances,

From the icons in Figure 4, designers can create new textile designs in a matter of hours rather than days or weeks. alongside the classification and codification of color as presented in Figure 4.

Therefore, customize pantone coloring a powerful design studio at fingertips that allows textile designers to:

- Modifying designs with advanced color management
- Using a variety of color modes.
- Including knits and weaves, as you create a choice of textiles and colorways.
- Printing digital textile design.
- Creating multiple colorways and palettes.
- Designing, creating and manipulating the textile prototypes.
- Repeats, drops, engraving sizes
- Work with different file formats.
- Allows the view of one repeat, many repeats, and real image size.
- Efficiently and quickly design custom fabrics and results appear immediately.
- Export multiple designs at once.
- Its user friendly workflow enables to make the textile design faster and error free.

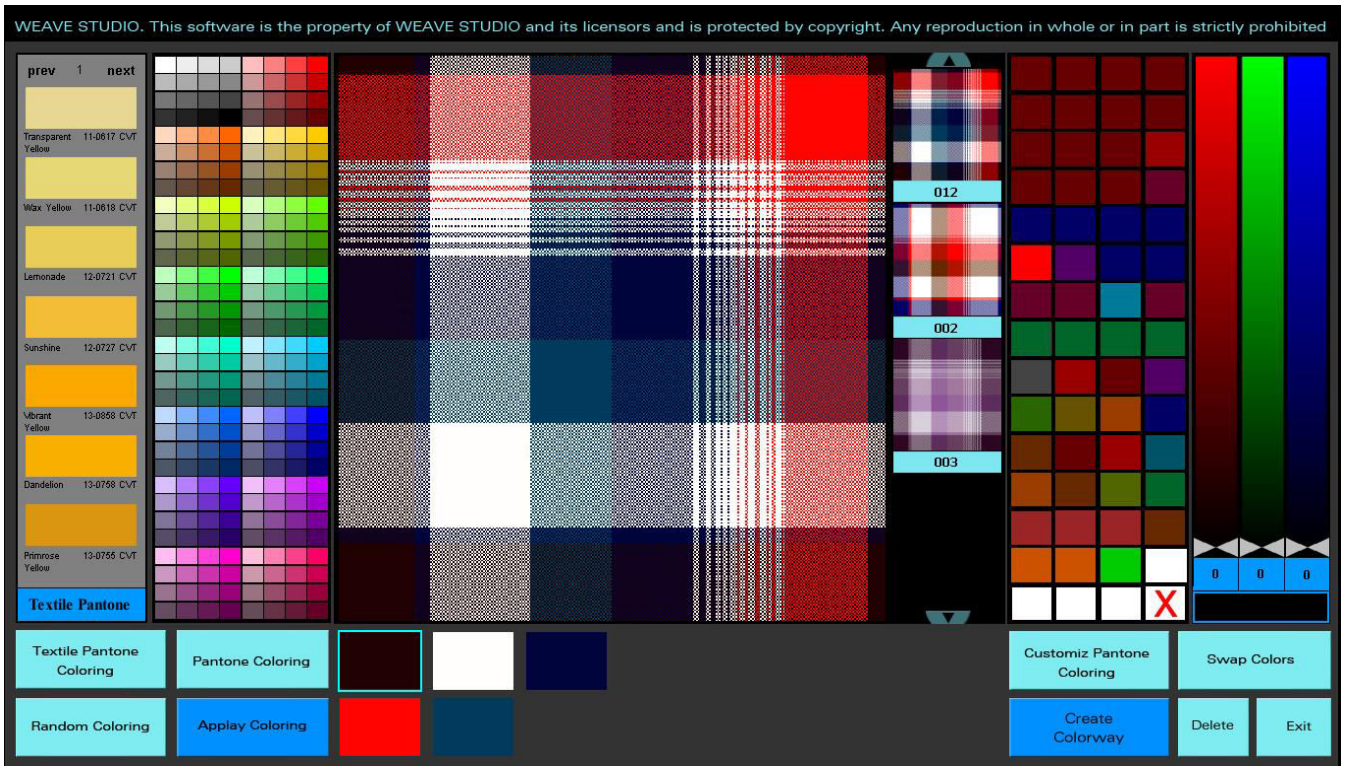

Figure 4. WeaveStudio customize pantone coloring.

V. WEAVESTUDIO EVALUATION

In this Section, we are going to present the empirical evaluation of usability and effectiveness of WeaveStudio. Each evaluation method is described with its methodology and the used metrics. After that, we continue with detailed discussion of the findings.

A. *Usability Evaluation (ISONORM 9241/110-S)*

The ISONORM 9241/110-S questionnaire was designed based upon the International Standard ISO 9241, Part 110 [21]. Recently, researchers have shown an increased interest in using this questioner for testing the user-friendly and usability [22]. Thus, we used this questionnaire as a general usability evaluation for the WeaveStudio toolkit. ISONORM questionnaire consists of 21 questions distributed into seven main Sections. Participants were asked to respond to each question scaling from (7) a positive exclamation and its mirroring negative counterpart (1) and it's used. The questionnaire comes with an evaluation framework that computes several aspects of usability to a single score between 21 and 147. A total of 34 questionnaires were completed. Table 3 illustrates the summary of the ISONORM 9241/110-S usability evaluation.

The majority of respondents were in the 23-42 age range. Male respondents formed the majority (90%). Participants have a high level of educational attainment: 66% of participants are studying bachelor's degree in Textile Technology and Design and 34% are worked in textile production.

TABLE III. ISONORM 9241/110-S EVALUATION MATRIX (N= 34)

Factor	Aspect	M	Sum
Suitability for design tasks	Integrity	4.6	
	Streamlining	4.9	15.2
	Fitting	5.7	
WeaveStudio Self-descriptiveness	Information content	4.9	
	Potential support	5.2	15.4
	Automatic support	5.3	
Conformity with user expectations	Layout conformity	4.9	
	Transparency	5.8	16.6
	Operation conformity	5.9	
Suitability for learning	Learnability	5.8	
	Visibility	4.9	15.5
	Deducibility	4.8	
Controllability	Flexibility	5.4	
	Changeability	4.9	15
	Continuity	4.7	
WeaveStudio Error tolerance	Comprehensibility	3.9	
	Correct ability	3.2	10.6
	Correction support	3.5	
Suitability for individualization	Extensibility	4.8	
	Personalization	4.7	14.7
	Flexibility	5.2	
ISONORM score		103	

The collect feedback from ISONORM 9241/110-S questioner reflect higher level of satisfaction; the total score was 103, which translates to "Everything is all right. Currently, there is no reason to make changes to the software in regards to usability"[21]. In particular, the handling of the WeaveStudio interface was considered by most of the designers to be easy and the majority reported that they did not have difficulties when going through the required textile design tasks (i.e. design coloring). The general design of the interface was perceived to be pleasant and interactive (i.e. every thing in one screen). Most designers also agreed that the used terminology and icons (e.g., Customize pantone coloring; create color way) were clear and self-describing. In general, the ISONORM 9241/110-S evaluation results reflect a user satisfaction with the usability of the WeaveStudio toolkit.

B. *Effectivness Evaluation*

In this Section, we will focus on the perceived quality and usefulness on the best practices of WeaveStudio. We will analyze the results per question basis for all textile design tasks. A summary of the average scores per question are given in Figures 5-10. Likert items are used to measure respondents' attitudes to a particular question.

The first question investigates if the proposed objective of WeaveStudio to make any suggestions for the client designs ideas. As shown in Figure 5, 64% of responders are strongly agree with that WeaveStudio helps them accurately interpreting and representing clients' designs ideas.

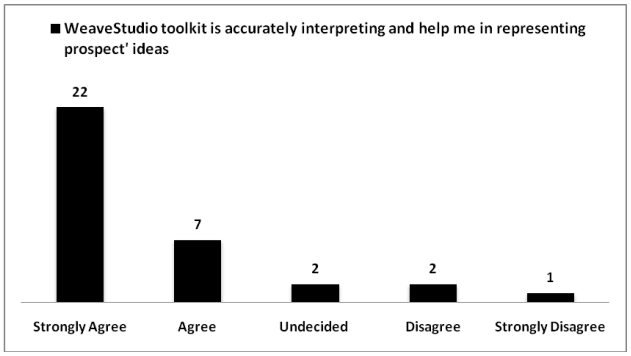

Figure 5. Representing clients' designs ideas

Further, we have observed that, applying color management on textile printing substrates. As can be seen from Figure 6, the overall response to the evaluation item is over 70% strongly agree with that WeaveStudio helps designers in understanding of color matching and color management issues for digital textile printing. This indicates that WeaveStudio toolkit is a powerful method for color management software in the field of digital printing onto a textile substrate.

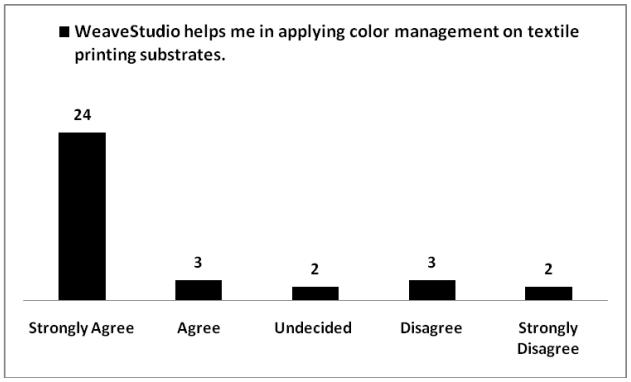

Figure 6. Applying color mangment in WeaveStudio

Moreover, participants in this survey are noted that, aggregate all the design elements in one screen (See Figure 4) is the best feature in WeaveStudio. Furthermore, following, we elaborate the ability of the WeaveStudio to produce novel and attractive in designing the structure and properties of nonwoven fabrics for different purposes.

It can be seen from the data in Figure 7, the majority are agreed that WeaveStudio enable them to create *beautiful* repeating patterns using different color patterns and make it possible to create a novel *textile design* for different perspectives.

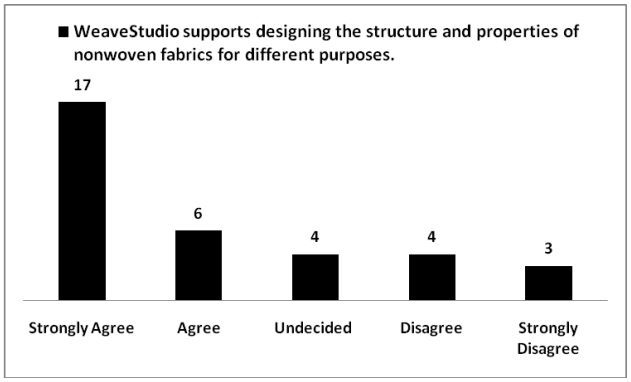

Figure 7. Novel and ttractive textile design

WeaveStudio further fosters customize panton coloring in order to improving the design of men's, women's and children's clothing for different purposes.

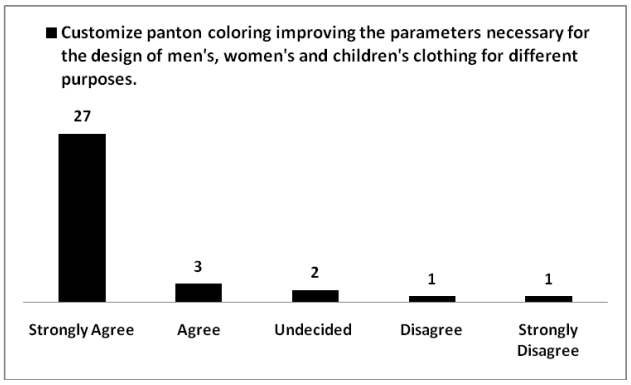

Figure 8. Customize panton coloring

In WeaveStudio designers can with the color picker in place, you can now integrate it with their design (Re-Coloring), the most used icons are presented in Figure 9.

Figure 9. Most used icons in WeaveStudio

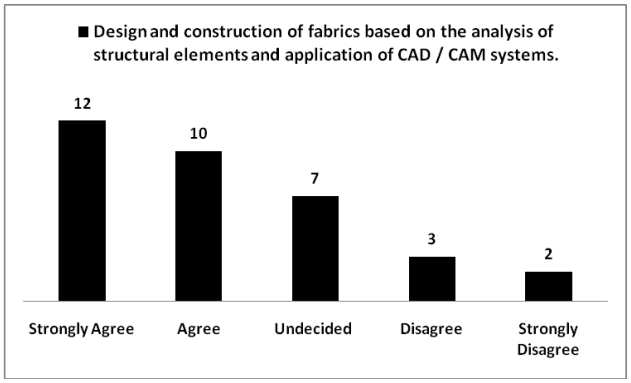

Figure 10. Supporting CAD / CAM systems

Computer-aided design (CAD) has brought a new revolution in the textile industry. In our context WeaveStudio helps textile designers to visualize and see their imaginative design in final layout without producing any cloths sample. The themes identified in these responses are summarized in Figure 10.

Finally, we asked designers whether WeaveStudio helps them to export and share design production-ready assets with textile developers. In Figure 11 there is a clear trend of agreeing that, WeaveStudio supports textile design artboards and helps them to export them individually to files.

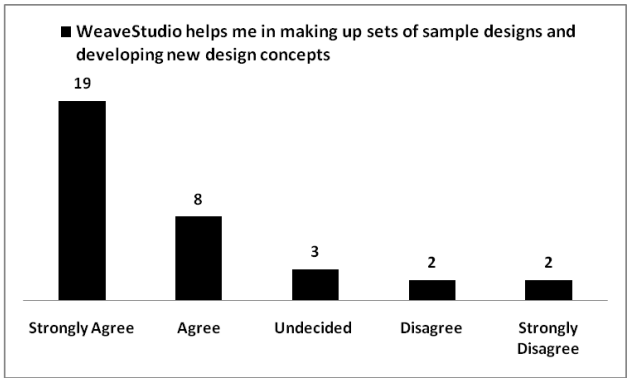

Figure 11. Export final textile designs

VI. CONCLUSION

Textile designing is a creative field that is important for a wide range of scientific and industrial processes. This study was undertaken to design, implement and evaluate the WeaveStudio toolkit as a textile designing solution for pattern coloring and visualization. WeaveStudio includes a dynamic interface of linked design data, supported by an integrated object-oriented technology. A combination of quantitative and qualitative approaches was used in the data analysis. The preliminary evaluation results revealed a user acceptance of WeaveStudio toolkit as a helpful, easy to use, and useful textile design tool that has the potential to foster customize panton coloring in order to

improving the design of men's, women's and children's clothing for different purposes.

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