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TABLE OF CONTENTS

FLEXO AND SCREEN PRINTING OF GRAPHENE/ MULTIWALL CARBON NANOTUBE HYBRID

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Abstract

In this work, we present the development of conductive graphene water-based inks suitable for printing of several themes on different kinds of papers based on flexography and screen printing techniques. The inks were prepared by a hydrophilic graphene/carbon nanotube hybrid and suitable mixtures of resins. The as-prepared conductive inks were stable, highly conductive and their printing quality was comparable with that of conventional commercial inks. Especially, for flexography, the relationship between printing quality and the ink-carrying volume of the cells of the anilox roll and the pre-inking was investigated.

Keywords: *Conductive inks, Graphene, Flexography, Screen printing*

Introduction

Printing has gained increasing attention due to its definitive contribution to the wide field of flexible printed electronics and the great interest of researchers in functional printing. Screen printing, gravure, flexography and inkjet are the technologies that are mainly used in printed electronics (Cruz et al 2017; Ng et al 2019). Flexography has been used for the development of transistors, conductive grids on-label battery testers, drug delivery patches, printed batteries, piezoelectric pressure or bio and gas sensors, photovoltaics and other applications (Morgan et al 2018). An important advantage of this method is its lower cost compared to the quite similar gravure, where cylinders are of high cost and limited lifetime (Cruz et al 2017). On the other hand, screen printing is simple, inexpensive, one of the most important industrial printing techniques and can integrate easily different printing systems as for example digital printing system. It is used widely for advanced applications such as the printed circuit production, the printing of

dye-sensitized solar cells or organic photovoltaics, the printing of biosensors or smart labels e.g. for augmented reality applications where we should note that flexography is also usable, the development of wearable electronics etc. (Wiklund et al 2021; Tsoukleris et al 2005; Singh et al 2022; Cruz et al 2017; Ng et al 2019).

However, the critical issue that needs to be noticed when applying printed electronics to these applications is the development of conductive inks (Koutsioukis et al 2017; Koutsioukis et al 2021, Belessi et al 2019). Up to now, commercial conductive inks are based mainly on metal (nano and micro particles), conductive polymers and carbon black or graphite while special interest has been given to graphene and graphene derivatives (Giasafaki et al 2022; Belessi et al 2019, Barmpakos et al 2021). Graphene is a monolayer of carbon atoms tightly packed into a two-dimensional (2D) honeycomb lattice that has found numerous applications due to its excellent electrical and thermal conductivity, mechanical strength and optical properties. A great advantage of graphene is that it could be produced at low cost from an abundant natural material such as graphite although, up to now, an efficient and with high yield production method has not been established (Georgakilas et al 2005). Graphene nanosheets are single or few-layered nanostructures, highly hydrophobic (not dispersible in water) and only poorly dispersible in a few organic solvents that are not proper for the preparation of inks due to toxicity, high cost or environmental affairs. In the literature, several surfactants or dispersing agents have been used to provide graphene with the necessary dispersibility but in most cases the conductivity of the inks was negatively affected.

The purpose of this study was to prepare graphene water-based inks with high conductivity and accepted printability properties appropriate for flexography and screen printing. The inks were formulated using a hydrophilic graphene/carbon nanotube hybrid and suitable water-based mixtures of styrene–acrylate and acrylic resins (Georgakilas et al 2015; Koutsioukis et al 2017). The printed patterns were of high quality and precision. Especially, the screen printed patterns showed remarkable conductivities due to the thicker ink film.

Materials

Graphite, Multi-Wall Nano Tubes (MWNTs), sarcosine, 3,4 dihydroxy benzaldehyde and dimethyl formamide (DMF) were purchased from Sigma-Aldrich. The water-based resin emulsions (44.2% solid content) were products under development that contain mainly a mixture of styrene–acrylate and acrylic resins and provided from Druckfarben Hellas S.A. The printing

substrates C 2846 (coated and calendared paper), smart-paper type 2 (special paper for printed electronics) and extra premium photo paper were obtained from IGT Testing Systems, Felix Schoeller Group and @work, respectively.

Preparation of Materials and Inks

The highly conductive and dispersible graphene/multiwall carbon nanotube hybrid (G/MWNT-*f*-OH) was prepared according to the methods reported in a previous work (Georgakilas et al., 2015). Briefly, 1.6 gr of graphene (G) was dispersed in 800 ml DMF and sonicated for 1h. Graphene dispersion was mixed with 0.4 g MWNT-*f*-OH (1 mg mL^{-1}). The mixture was stirred overnight and the hybrid G/MWNT-*f*-OH was isolated by rotary evaporation (65 ℃, 120 rpm) and dispersed in 10 ml of water. This method was followed up to produce the necessary amount of the hydrophilic hybrid for the ink preparation.

One of them was formulated for screen printing (with total solids carbon/resin ratio 55/45) and the other two for flexography (with total solids carbon/resin ratio 55/45 and 70/30) (Table 1). Specifically, 1 g of the G/MWNT-*f*-OH was mixed with 0.97 g resin emulsion (44.2 % solid content), in totally, water volume was 9.9 mL to prepare ink suitable for flexography printing at solids carbon pigment/resin ratios of 70/30. That ink is symbolized as Flexo Ink70-30. Similarly, an ink at solids carbon pigment/resin ratios of 55/45 was prepared for flexography printing. 1 g of the G/MWNT-*f*-OH hybrid was mixed with 1.83 g resin emulsion (44,2 % solid content) and 12.1 mL deionized water. That ink is symbolized as Flexo Ink55-45. Finally, 1 g of the G/MWNT-*f*-OH hybrid was mixed with 1.83 g resin emulsion (44,2 % solid content) and 5 mL deionized water. That ink is symbolized as Screen Ink55-45. The mixtures were stirred for 2h to homogenize. For all inks, commercial resin emulsions were used to reduce their cost and improve their printability.

Characterization of Materials and Inks

The printing inks were fully characterized by various methods such as Scanning Electron Microscopy (SEM), Tunneling Electron Microscopy (TEM), electrical and rheological measurements. SEM images were collected using a Hitachi 6600 Field emission scanning electron microscope operating in the secondary electron mode and using an accelerating voltage of 5 kV. Microscopic analysis of the samples was performed using TEM (JEOL-JEM 2100). The values of V/I and sheet resistance (Rs) calculations of the hybrid, the printing inks and the printed patterns were measured by a 4-point probe system (Pro4 Resistivity System, Lucas Labs) and a Keithley 2400 Source Meter.

Printing

Initially, the graphene nanohybrid inks were applied on various papers, common or special, with the wired K-Bars (RK Print Coat Instruments Ltd., United Kingdom) numbered as 1 (6 μm wet film deposition) in order to choose the most appropriate types of paper.

Flexographic printing was performed with the IGT F1 printability tester. A printing plate was developed with respect to photopolymer hardness (70 Shore A). Four different anilox rollers (2.7, 4, 8 and 16 ml m^{-2}) and various printing speed (0.2 – 1.5 m s^{-1}) where used to determine the ink volume and speed effect, respectively. In all experiments, the anilox/printing force was 50 N and doctor blade pressure 6 N. Printability tests were first carried out by conventional ink in order to examine printing image design on flexographic plate and plate quality.

Preliminary screen printing tests of the conductive inks were performed using a manual screen printing machine (one colour, one station Kunshan), an aluminium screen printing frame with 90T mesh count (PE AM 90.48 PW, Saati) and a squeegee.

Results

The G/MWNT-*f*-OH hybrid was dispersed in mixtures of commercial water-based resins giving stable inks for flexo and screen printing. Figure 1 presents representative SEM and TEM images of the carbon hybrid. The Rs of the carbon hybrid and its ink were measured to be 9 Ohm sq^{-1} (e.g. 20 μL of 20 μg μL^{-1} of a hybrid suspension) and 16 up to 45 (depending on the resin content) Ohm sq^{-1}, respectively (Table 1). It was observed that the higher the total solids carbon/resin ratio the lower the Rs.

Table 1

Ink	Total solids carbon/ resin ratio	Pigment solids/ink solids	Resin solids/ ink solids	Total solids in ink (%)	Pigment solids in ink (%)	Ink Rs (Ohm sq^{-1})
Flexo Ink 70–30	70/30	0.70	0.30	12.04	8.42	16
Flexo Ink 55–45	55/45	0.55	0.45	12.12	6.70	45
Screen Ink 55–45	55/45	0.55	0.45	23.10	12.77	45

The viscosities of all inks were tuned to be printable for the two methods. The study of the rheological properties of the inks, that is not presented in this work, showed that they exhibit shear thinning properties in accordance with our previous work (Koutsioukis et al., 2021). In Figure 2 (left) are shown representatively printed patterns with flexography, using the G/MWNT-*f*-OH inks with the two different total solids carbon/resin ratio, 70/30 and 55/45, printed on the same IGT-coated paper. In Figure 2 (right) is shown a representative photo during the measurement of the V/I of a printed pattern with flexography. It was found that print quality and Rs values of the inks were improved for the flexo ink with the total solids carbon/resin ratio of 70/30 compared with that of 55/45.

Also, the effect of wetting of the printing plate was examined by the pre-inking process of the plate before printing, using the ink with the total solids carbon/resin ratio 55/45. The time between pre-inking and printing was critical because of ink drying. It was found that pre-inking increases the amount of applied ink and so the print quality (Figure 3). Furthermore, the ink-carrying volume of the cells of the anilox roll was shown to have a

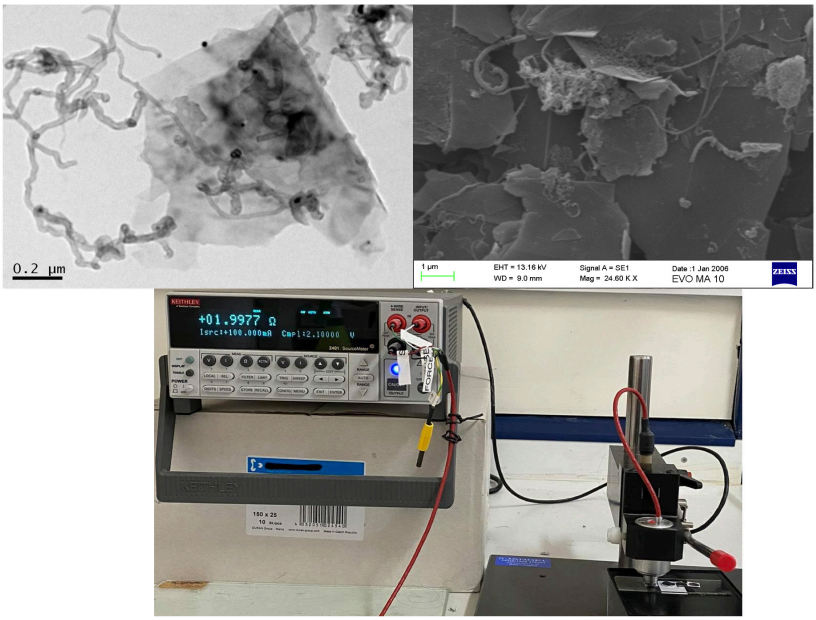

Figure 1. Representative TEM (Up and left) and SEM (Up and right) images of the carbon hybrid (Down) Measurement of the V/I of the hybrid

dominant effect on the print quality and affects ink film thickness. Specifically, the higher the anilox volume of the cells the better the print quality. Thus, it was chosen for all experiments the use of the anilox with a volume of 16 ml m^{-2} and pre-inking before all experiments. The Rs values of the flexo printed patterns were deviated between 2.3 and 44 kOhm/sq depending on the printed structure (e.g. the width of line). The Rs values are high due to the low thickness of the printed patterns (< 1 μm) but can be decreased when multilayer printing is applied (Ng et al 2019). Finally, various printing tests with the water-based carbon nano ink were carried out and found that the effect of printing pressure and printing speed had no significant effect on print quality.

The composite hybrid was used for the development of an ink, with total solids carbon/resin ratio 55/45, suitable for screen printing. This method has become a reliable and accepted printing solution for the application of conductive inks, facilitating high volume and low-cost production (Cruz et al 2017). Various structures like antennas, meanders or other simple symbols have been designed from our group, and found that they were easily fabricated using the screen printing method. Representative photographs of the screen printed patterns using the G/MWNT-*f*-OH nanohybrid are shown in Figure 4. The Rs of the screen printed patterns were below 2.5 kOhm/sq, mainly due to the thicker screen printed layer compared to flexography (Ng et al 2019).

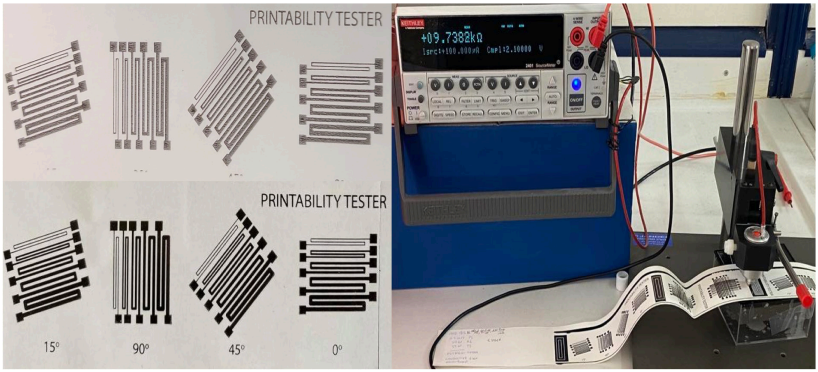

Figure 2. Flexography printed patterns, on the same paper, using the G/MWNT-f-OH hybrid with total solids carbon/resin ratio (left and up) 55/45 (left and down) 70/30. (Right) Measurement of the V/I of the printed pattern (with total solids carbon/resin ratio 70/30)

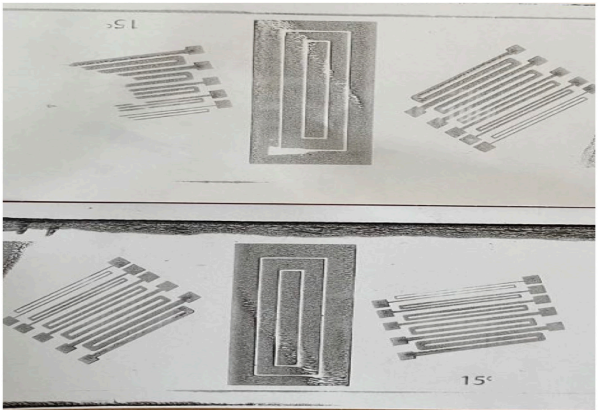

Figure 3. Flexography printed patterns, on the same paper, using G/MWNT-f-OH hybrid with total solids carbon/resin ratio 55/45 (up) without pre-inking and (down) with pre-inking

Figure 4. Representative screen printed patterns using the G/MWNT-f-OH hybrid with total solids carbon/resin ratio 55/45 printed on (left) smart-paper type-2 and (right) extra premium photo paper

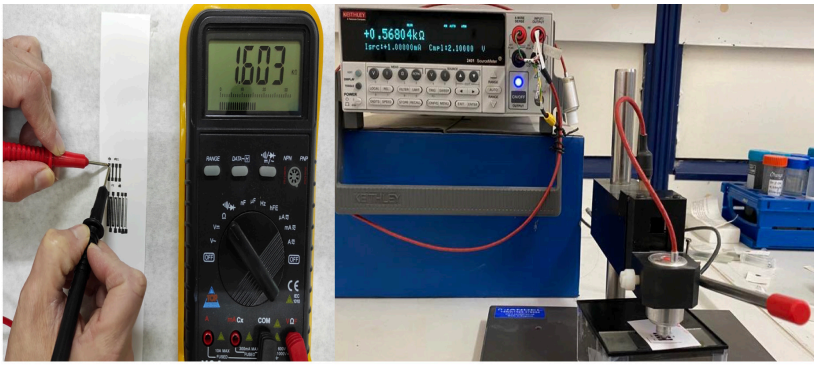

Figure 5. Various V/I measurements of the screen printed pattern

Conclusions

The as-prepared highly conductive inks were storage stable and printable. Higher Rs values were received for the flexo printed patterns compared to screen printing. Also, it was found that pre-inking increases the print deposition and the print quality.

Usually, stabilizers are required to prevent agglomeration in most inks, and also post-print treatments are necessary, but none of them was demanded in this work. The key property for achieving high-quality conductive printing inks was mainly the excellent dispersibility of the graphene/multiwall carbon nanotube hybrid.

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EVALUATION OF FINE ARTS PRINT PRODUCTION WITH ARTIST'S OPINIONS IN CONTEMPORARY ART PRESENTATION

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Abstract

Fine art printmaking is a process that involves creating multiple original artworks through various printing techniques such as etching, lithography, and screen printing. Printmaking has been a significant art form for many contemporary artists, and its value lies in its ability to reproduce artworks in a way that is more affordable and accessible to a broader audience. In the last three decades, rapidly advancing digital technology has caused radical changes in many social, cultural, and economic fields, including the presentation of contemporary art. This has led to the formation of an innovative attitude among artists, which has transformed and triggered the production of new artworks. Fine art prints, which are considered one of the original printing methods, have become increasingly popular among contemporary artists as a means of bringing their works to wider audiences and generating additional income.

Digital technologies offer a new tool for artists, which can be used to create dynamic visual presentations in different spaces and platforms. This innovative attitude that fine art prints bring to the behaviour of today's artists should be considered alongside other contemporary art presentations. The aim of this article is to investigate the effects of digital printing technology and fine art prints on contemporary artists. To achieve this, in-depth interviews were conducted with 15 participants, including well-known artists and art institution managers, in the contemporary art scene in Turkey. The findings were analyzed using content analysis, a qualitative research method, which helped to identify the concepts and relationships that could be explained with a theoretical expression based on the interpreted data.

Keywords: *Fine art Prints 1, Contemporary Artist in Turkey 2, Printmaking Art 3, Art production 4*

Introduction

"The development and adoption of computer technology after the Second World War led to increased demands in business and the development of communications methods. It is possible to see these developments, especially in the printing industry, which has existed commercially since the 16th century. Digital technology has brought advancements in the printing industry to light, enabling personalized designs that can be printed on any surface. The first intersection of digital technology with the art world was created by the applications experienced by photographers and artists. Photographers and artists, first of all, have applied digital imaging methods to develop their own art. These methods have created demands and, thanks to scientific studies, have improved the image quality of inkjet digital prints. In this context, as the inks become more resistant to fading in the light with a wider range of colours, artistic works designed by contemporary artists in the digital environment can be produced with fine art printing methods and find a place in contemporary art museums and collections. In this context, it is stated that digital technology shapes cultures and societies with its indispensable representation power in every field. In this representation, art plays an important role in shaping the expression of social emotions and life by taking the support of technology (Schiuma, 2011).

In today's art landscape, digital technology has emerged primarily as an online marketplace that sells affordable paintings, prints and drawings to regular customers of museums and auctions. In this way, hundreds of unknown artists now have access to an online market that deals with all these purchasing and promotion processes and get the chance to watch all kinds of. However, some interpret that digitization in art means that quality is declining as anyone with a computer can now paint or draw and has access to a large number of customers online. In other words, it means that art becomes less privileged and thus loses the sense of uniqueness or beauty. The opinions of the auction sales sites in the art market on the digital platform against this negativity are; is that this is not the case, quality is the key and its maintainability continues. It is stated that it is not easy to enter the private circle of artists on an auction site such as www.curioos.com, which is one of these sites. It is stated that the artists are only invited or jointly selected by other artists and only 15% of them can take place in a very selective environment where they can exhibit their works on the website.

One of the other important criteria is that the selected works are numbered and printed in limited numbers – signed by the artist, in editions – which helps to preserve their values. In this way, the quality of the work is maintained through this changing process. Additionally, this approach

reflects how young art lovers are buying art today, providing an important tool for greater access and education about their particular tastes. (Oudea, [18.01.2017]).

Methodology

The data for this research, which aimed to evaluate the views of 15 contemporary artists and art institution managers, were obtained through in-depth interviews conducted as part of a qualitative study. The interviews took place over a 6-month period in 2021, under the conditions of the COVID-19 pandemic. Participants were given the option to answer questions face-to-face, via email, or online. The interviews were conducted impartially, and every comment was recorded without interruption. The data obtained were analyzed using the MAXQDA program and expert opinions. To increase the validity of the research, some of the participants' statements were directly included in the data, and expert opinions were sought to examine the study in terms of its dimensions. The credibility of the research was further increased by comparing the researcher's themes and coding scheme with expert opinions. A desired level of reliability was considered to be achieved in cases where the agreement between the coding scheme was 90% or higher. The obtained values were interpreted and presented as meaning maps and tables.

Digital Printing Applications in Contemporary Art Production

Jack Duganne, a printer and printing engineer, introduced the term "Giclée" around 1990 to describe the process of digital art printing using inkjet printers. This innovative term was coined to differentiate high-quality inkjet prints from the low-quality printing often associated with inkjet technology. Duganne, who worked as a printer at Nash Editions, used the term Giclée to refer to proofs from an industrial pre-press high-resolution inkjet printer called "Iris". Over time, Giclée has become an accepted term in the print industry to describe high-quality digital art prints of original works or computer-generated artworks. This term is now widely used to describe the modern printing technique that has revolutionized the art world. (capcityrepro, [03.05.2018]).

Artists have been using digital printing technologies in their creative process since the 1990s. However, early digital art prints produced by Iris printers were found to fade or deteriorate over time. Thankfully, advancements in technology have significantly improved the durability of ink and substrate materials used in digital printing, thereby eliminating these issues (Nickelson, 2017). As a result, the digital environment has become a new

medium for archiving artwork and producing fine art prints with minimal effort and cost for the artist. By using a professional color separation process, artists can create limited edition prints with their personal control, signature, and desired number of copies. This allows them to offer original prints to a certain number of buyers and restrict the sale of their work. By sharing the material value of the artwork between a few buyers, artists can make their work accessible to low-budget art lovers at affordable prices. By embracing this process, contemporary artists can expand their reach and contribute to the development of this new medium.

Contemporary artists face a significant challenge in navigating the complex process of digital printing and understanding the different stages involved, as noted by Berger (2005). This stage of production requires the artist to grapple with the constantly changing world of digital printing technology and often necessitates the assistance of an expert in preparing the original work. Achieving high-quality, durable prints that resist fading over time involves several factors, including selecting appropriate ink and media combinations, assessing the longevity of the print, and considering finishing options like polished or canvas prints. With this, digital art production requires different skills and knowledge compared to traditional art-making methods. Although an artist may be proficient in traditional art materials, they may have limited knowledge and experience in digital production techniques. To produce high-quality prints, artists must either work with a professional in a reliable studio environment or invest significant time and money in extensive research and professional training. In this context, the high costs associated with machinery and consumables can pose a significant barrier for many artists. Therefore, digital art production is more commonly used by well-known artists in the art market. Some contemporary art museums, such as Istanbul's Graphic Arts Museum (IMOGA), have established fine art printing studios to support artists in this field.

Analysis and Findings

E. Gombrich draws attention to the fact that the Age sometimes determines the art and sometimes the art determines the age, and the relationship of the spirit of the age with art movements (Gombrich, 1993, 3). W. Benjamin, on the other hand, mentions that in addition to the tremendous change that mechanical reproduction brought to literature, techniques such as wood, metal engraving and lithography in the Middle Ages brought the production technique of art to a new level. He emphasizes that the mechanical reproduction of a work of art expresses something new, while graphic art allows it to take place in the market, just like Ukiyo-e, lithography accompanies

the graphic art of daily life with pictures. Accordingly, it is suggested that print art is a social medium, its social nature and the role of social relations and power structures in the artist's negotiation of these dynamics should be taken into account. Considering these interactions, it is emphasized that artists are led to question the power and importance of the art object, as well as to reflect on their responsibility and capacity to report on and engage with current events (Crawford, 2021, 2).

Since information technologies have taken over all of the dynamics of social life with the digitalization of information, some contemporary artists have turned to artistic presentations in which human beings are not involved and in which they adopt the interdisciplinary production relationship by using new virtual information. These innovative information technologies have also provided opportunities for brand-new expansions in their presentations for artists. Starting with sample photography and video, internet art, multimedia art, software art, artificial intelligence happening, viral art, e-mail art, virtual world performance, or NFT etc. with the derivatives, the diversity of artistic expression, which is called new media art, has increased. In addition, as a digital production technique, fine art prints are also a new production technique alongside traditional original printing methods such as lithography, engraving, and wood printing. In this way, art repositions itself in the new world order by reaching wider masses. In this direction, it is possible to say that art is now separated from the traditional one.

In this research, with the participation of 15 interviewees, including contemporary artists and art institution managers in Turkey, the expressions of digital art print works on the visual art phenomenon were evaluated. Themes obtained from the findings expressing personal and professional characteristics were presented and interpreted in the form of maps and tables.

Evaluation of Findings

The research consists of 15 interviewees, who are well-known painters in Turkey, who produce contemporary art, expert academicians, sculptors, textile artists, printmakers and art gallery managers. All of the interviewees consisted of two women and thirteen men, who were educated in fine arts and are experts in their fields. The interviewees consist of a mixed group of people between the ages of 37-82 who are interested in and produce digital art in a wide range of traditional ways. At the beginning of the analysis, codes were given to each of the participants first. (Table 1).

Table 1. Descriptive information about the study group

Interviewer Code	Age	Gender	Level of Education	Profession
1 (A.G.)	77	M.	Bachelor/1974	Artist, Academician
2 (A.N.)	67	M.	Bachelor/1984	Artist, Sculptor
3 (C.A.)	54	M.	Bachelor/1986	Artist, Academician
4 (C.K.)	61	M.	Bachelor/1995	Artist, Academician
5 (E.T.)	53	W.	Bachelor/1997	Art Gallery manager
6 (G.D.E.)	67	M.	Bachelor/1979	Artist, Academician
7 (H.K.)	55	M.	Bachelor/1993	Artist, Academician
8 (H.E.)	55	M.	Bachelor/1987	Artist, Academician
9 (M.G.)	63	M.	Bachelor/1981	Artist, Academician
10 (M.Ö.)	37	M.	Bachelor/2005	Artist, Academician
11 (M.T.)	52	W.	Bachelor/1997	Artist, Academician
12 (M.B.)	55	M.	Bachelor/1986	Artist, Academician
13 (S.S.T.)	82	M.	Bachelor/1961	Artist, Academician
14 (T.B.)	45	M.	Bachelor/2002	Printmaker, Academician
15 (T.A.)	57	M.	Bachelor/1986	Artist, Academician

Content analysis, one of the qualitative research methods, was used in the analysis of the data obtained from the in-depth interviews with the participants. In the research, coding and sorting were done first in the process of analyzing and interpreting the data. After the coding of the interviewees, the three main headings with the highest frequency values among the themes obtained by classification according to the stages were examined (Figure 1).

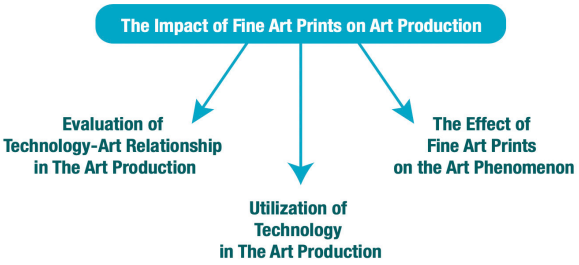

Fig 1. The semantic map of the impact of Fine Art Prints on art production

When the findings obtained in the research were evaluated, it was seen that in terms of percentage values in the interviews, it was structured as 3 main themes with the titles "Utilization of Technology in the Art Production", "Evaluation of Technology-Art Relationship in the Art Production" and "The Effect of Fine Art Prints on the Art Phenomenon". The frequency values related to these main themes are shown in Table 2.

Table 2. Interviewers' view on the main themes

The Main Themes	f	%
Evaluation of Technology-Art Relationship in The Art Production	113	38,44
Utilization of Technology in The Art Production	59	20,07
The Effect of Fine Art Prints on the Art Phenomenon	90	30,61
The other Themes	32	10,88
TOTAL	294	100,00

Evaluation of "Technology-Art Relationship in Artistic Production"

To the interviewees forming the working group, *"How do you evaluate the relationship between technology and art in today's contemporary art environment and artistic production?"* the question was asked and when the findings were evaluated, the data obtained within the scope of *"Evaluating the technology-art relationship in artistic production"*, which is one of the 3 themes, were coded within the scope of positive and negative effects (Figure 2).

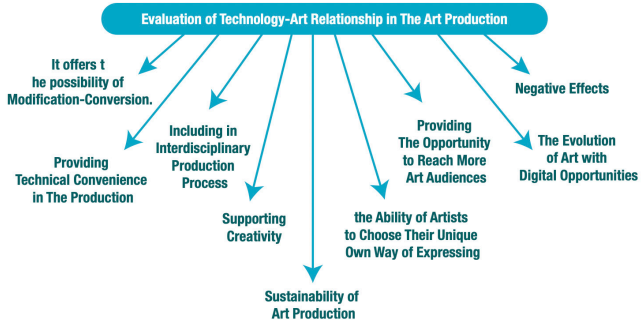

Fig 2. The semantic map of Evaluation of Technology-Art Relationship in The Art Production

When the findings related to "*Evaluation of Technology-Art Relationship in Artistic Production"*, which is one of the main themes, are evaluated; As seen in Figure 2, *"Providing technical convenience in production", "Evolving Art with Digital Opportunities", "Supporting creativity", "Involving in the interdisciplinary production process", "Choosing a unique way of expression for artists", "Providing the opportunity to reach more audiences". and "Sustainability in production"* were revealed and coded within the scope of positive effects. Apart from these sub-themes, "Criticisms about originality" found in the expressions of artists and art institution managers were coded under the *"Negative effects"* sub-title. Frequency values related to these sub-themes are shown in Table 3.

Table 3. Evaluation of Technology-Art Relationship in The Art Production

Evaluation of Technology-Art Relationship in The Art Production	**f**	**%**
Providing Technical Convenience in The Production	45	40,55
The Evolution of Art with Digital Opportunities	25	22,5
Supporting	9	8,1
Negative effects	9	8,1
Including in Interdisciplinary Production Process	8	7,21
the Ability of Artists to Choose Their Unique Own Way of Expressing	6	5,43
Providing	5	4,5
Sustainability of	4	3,6
TOTAL	111	100,00

Within the scope of the relationship between technology and art, technology provides convenience in the technical field; In the context of providing new possibilities and manipulation possibilities on basic tools, facilitating and facilitating the process, the participants; stated within the scope of positive opinions that technology shortens the production process, provides creativity, and provides a more practical and faster art production.

In the scope of adverse effects; Expressions such as being misleading, imitating and copying some works, unfair use of technology and causing alienation between the producer and the produced were expressed.

Evaluation of "Use of Digital Technology in Art Production"

To the interviewees forming the working group, "How do you evaluate the relationship between technology and art in today's contemporary art environment and artistic production?" the question was asked and when the findings were evaluated, the data obtained within the scope of "Utilization of Digital Technology in Art Production", which is one of the 3 themes, were coded within the scope of positive and negative effects.

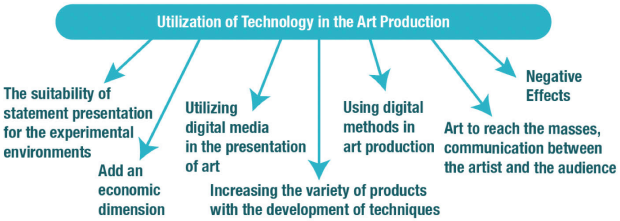

Fig 3. The semantic map of Utilization of Technology in the Art Production

When the data obtained in art production are evaluated; *"For the artist, the compliance of expression presentation to the experimental environments", "Utilization of digital channels in the presentation of art", "Using digital production methods in art production", "Economic dimension", "The reaching of art to the masses, and the communication between the artist and the audience", "With the development of techniques, the increase in diversity in art production",* and "*The negative effects"* come to the forefront and are shown in Figure 3.

Table 4. Utilization of Technology in the Art Production

Utilization of Technology in the Art Production	**f**	**%**
The suitability of statement presentation for the experimental	7	11,86
Increasing the variety of products with the development of techniques	5	8,47
Art to reach the masses, communication between the artist and the audience	9	15,25
Add an economic dimension	3	5,08
Using digital methods in art production	23	38,98
Utilizing digital media in the presentation of art	11	18,64
Negative effects	1	1,69
TOTAL	59	100,00

As seen in Table 4, when the findings regarding one of the main themes "Using the digital method in art production" are evaluated; Concepts consisting of the most frequently mentioned facts and interpretations such as "Image processing programs", "Using digital art printing methods", "Using digital methods in the artistic production process" were coded under the "positive effects" sub-headings.

Apart from positive concepts, "Being misleading" in the statements of artists and art institution managers was coded under the "Negative effects" sub-title. Frequency values for these sub-themes are also shown in Table 4.

In the statements of the participants regarding the relationship between technology and art and the facilities provided by technology in the technical field; Positive opinions were given about providing new possibilities and manipulation possibilities on basic tools, accelerating and facilitating the process, shortening the production process of technology, providing creativity, and providing more practical and faster art production.

Evaluation of "The Effect of Fine Art Prints on the Phenomenon of Art"

When the findings obtained from the interviews were evaluated in the research, the positive and negative effects of the data obtained regarding "The Effect of Fine Art Prints on Art Phenomenon", which is one of the 4 themes, were coded. When these data are examined; "Technology Accelerating and Developing Artistic Production", "Artistic Value of Works Produced by Digital Printing Technology", "Artist's Status and Perspective of Digital Art Print Work Production", Views on Art Production with Digital Printing", Opinions Regarding the "Artworks in Exhibition-Collections", "Interactive with the Artist and Her/His Work" The meaning map of the positive and negative effects such as "Establishing Communication" is shown in Figure 4.

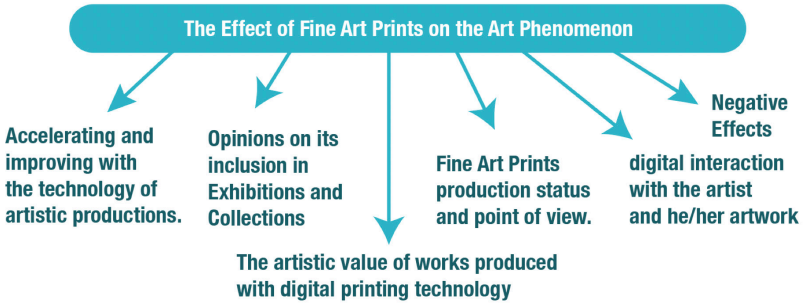

Fig 4. The semantic map of The Effect of Fine Art Prints on the Art Phenomenon

Table 5. The Effect of Fine Art Prints on the Art Phenomenon

The Effect of Fine Art Prints on the Art Phenomenon	f	%
Accelerating and improving with the technology of artistic productions.	18	20
The artistic value of works produced with digital printing technology	17	18,89
Fine Art Prints production status and point of view	37	41,11
Opinions on its inclusion in Exhibitions and Collections	9	10
Digital interaction with the artist and own artwork	3	3,33
Negative effects	6	6,67
TOTAL	90	100,00

One another main theme is when the findings regarding the evaluation of effect of Fine Art Prints on the phenomenon of art are evaluated; The concepts constituting this main theme were revealed and coded within the scope of positive effects, as seen in Figure 4. Apart from the positive concepts, the opinions of the artists and art institution managers that "according to the idea that digital technology is not art, the buyer doesn't want it, as well as its tendency to be imitated and reproduced far from uniqueness" were coded under the sub-title of "Negative effects". The frequency values for these sub-themes are also shown in Table 5.

In the statements of the participants about the effect of Fine Arts Printing on the phenomenon of art; "As technology improves art production, makes it more practical and adds new dimensions to the field, they expressed positive opinions about how fine art prints interact with technology. Negative statements within the scope of negative effects are: "Not having enough technical knowledge and not having time for training", Expressions such as "Concern that the recipient will see it as worthless", "The classical work of art is perceived as more valuable", "Concern for reproducibility" and "The artist does not prefer to use digital techniques in production" are coded under the sub-title of "Negative effects".

Conclusions

It's uncertain how digital technology will affect artistic vision. Since the 1960s, engineers have invited artists to explore this innovative production environment. The development of digital technology has led to changes in the art environment, with fine art prints being accepted as an original with the artist's signature. While some main artists have been hesitant towards

digital print artworks, the majority of well-known artists in the Turkish art market have a positive view. To see real change, collective practices and developments need to be presented to the artists. Once concerns and fears are addressed, clearer results regarding the impact of fine art prints on the art world can be observed.

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STUDY OF THE INFLUENCE OF THE SURFACE STRUCTURE OF THE SUBSTRATES ON THE IMPRINTS QUALITY

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Abstract

Modern printing technologies allow the use of a diverse range of materials for printing to satisfy the requirements of the most demanding consumers. However, the quality of the imprint is not always satisfactory. Of course, there can be many reasons: non-observance of technological printing modes, problems related to setting up the operation of the main and auxiliary mechanisms of the printing machine, problems of transporting material through printing and inking units, etc. One of the problems of obtaining a high-quality imprint in all printing methods is compliance with certain technological requirements regarding the selection of the properties of the printed materials, in particular their surface. Properties of the printing base surface are one of the most important factors affecting the completeness of the image transfer and the appearance of the imprint.

Based on the methods of system analysis, hierarchical groups of imprint quality indicators in flexographic and digital printing methods, which ensure high imprint quality, are singled out. Accordingly, studies of the surface topography of imprints on paper and cardboard with and without a chalk coating, as well as on film materials (in flexographic printing technology) were conducted.

The surface topography of imprints on various materials was experimentally investigated. A change in the morphological structure of the substrate surface before and after printing was revealed. It has been studied that the presence of a chalked coating, which changes the parameters of roughness and the area of peaks and valleys on papers and cardboards, has a significant effect on the microgeometry of the surface. The method of surface treatment of film materials also affects the topography of imprints surface. It has been confirmed that with an increase in the number of surface coating layers on the substrates, the roughness parameter decreases significantly. The morphological structure of the surface of the materials before printing is preserved on imprints, but its smoothing is observed to a greater or lesser extent depending on the printing method used to obtain the printed image. Also, the indicators of the surface structure of the

imprint are affected by the characteristics of inks, varnishes, the method of imprints finishing, for example, by the lamination. This is confirmed by the results of electron microscopy.
Based on the results of experimental studies and taking into account the ISO model, a conceptual model and algorithm for the functioning of imprints quality assurance system were proposed, which take into account the problems associated with the dependence of the parameters of the surface structure of printed materials.
***Keywords**: imprint, quality, substrate, surface structure, system analysis.*

Introduction

Today, consumers of all countries of the world put forward increased demands for the decoration of packaging and sanitary-hygienic products. Therefore, printing companies use various printing and finishing technologies to meet their requirements. A wide and diverse assortment of packaging materials prompts manufacturers to study in detail all possible factors affecting the quality of imprints and their decoration. Lamination is a popular method of imprints finishing (Havenko, Dovhanych 2021).

The Ukrainian market of sanitary and hygienic products in terms of assortment and number of segments practically does not differ from the European or American one, but at the same time it is disproportionate – according to various estimates, from 70 to 80% is made up of toilet paper (Andrievska 2012; Andriyevska 2010), ("Market of sanitary" 2022), (Kalashnyk, Moroz 2008). And the products of this category of goods are very diverse and the need for them is growing every year, especially napkins. In addition, product consumers prefer printed napkins, which often become an attribute of celebrations, anniversary events, etc. That is why research on the quality of printing on napkins is relevant. In particular, such studies relate to the determination of densitometric and colorimetric indicators of images on imprints; identifying factors that affect the quality of this type of product.

Methodology and equipment

The aim of the study was to determine the morphological structure of the materials surface of imprints on them, obtained by flexographic and digital printing methods, and systematize factors influencing densitometric, colorimetric indicators of the quality of printed images.

The objects of the study were flexographic and digital imprints on UPM Digi Color cardboard with a grammage of 200–300 g/m^2 and two-layer paper of Huchtemeier Papier Gmbh with a width of 33×33cm.

UPM Digi Color paper (Finland) is a high-quality pure cellulose paper for digital printing, designed specifically for dry toner devices with sheet or roll paper feed (Table 1).

Table 1. Technical characteristics of UPM Digi Color papers (Finland)

Density (ISO 536), g/m	3
Fullness (ISO 534), g/m	1,05
Brightness D65, (ISO 2470-2), %	114,0
Whiteness CIE	170,0
Opacity (ISO 2471), %	99,7
Roughness	50

Huchtemeier Papier Gmbh tissue paper is made of bleached cellulose fibber, where all layers of the product are fixed. The paper is not corrugated, not chalked, not embossed, not perforated, without watermarks, without coating and not impregnated with special substances, does not contain fibbers obtained mechanically (Table 2).

Table 2. Characteristics of tissue paper Huchtemeier Papier Gmbh

Indicator	Value	Test method
Tensile strength	900–1000–800	SCAN P 44:81
Tensile strength	450–500	SCAN P 44:81
Weight	18,5±0,5	ISO 536
Thickness	2	SCAN P 66
Colour	white	Visually
Pliability	17	On
Humidity	5,5	On

The MICRO MEASURE 3D station profilometer, whose action is based on a non-contact method, was used to study the morphology of the surface of cardboard, papers and imprints on them. The surface structure of the substrates and imprints on them was studied on the AniCam installation of the company TROIKA Systems Limited, equipped with a 24-bit colour camera with a resolution of 640×480 pixels and a field of view from 1.25×0.92 mm. A three-dimensional image of the surface structure was obtained from the analysis of digital photographs of the surface of the substrate and the imprint

(measurement accuracy is ±1%). A test form was created to determine the densitometric and colorimetric characteristics of imprints (Fig. 1). A Konica Minolta FD-5bt spectrophotometer and a GRETAG SPM50 densitometer were used to study imprints. The values of optical densities and colorimetric indicators were compared with the values determined by international ISO standards (ISO 12647-6, 2017), (ISO 12647-2, 2008).

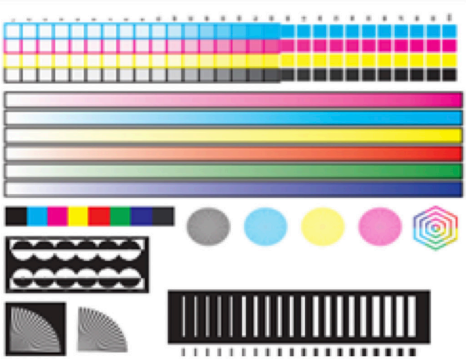


Fig. 1. Scale for studies of imprint quality

Imprints were obtained on a digital printing machine XEROX 700i Digital Color Press and a flexographic machine OMET TV 503 Lecco. Environmental water-soluble flexographic inks of the company Aquaflex Plus were used to apply the image by the flexographic printing method. Before use, they were mixed well and the required amount of water was added to obtain the required viscosity. The printing viscosity depends on the speed of the machine, so the ink must be diluted 10–20% with water to obtain the following range of values: 17–20 seconds. For laminating imprints, Lamiroll Glossy polypropylene film (PPL) with a thickness of 24 μm and a RL300 model roll laminator was used.

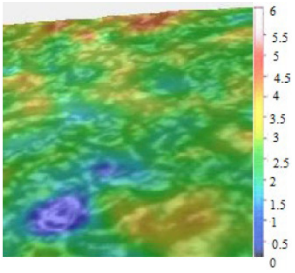
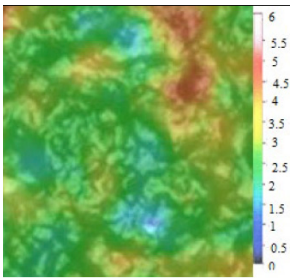
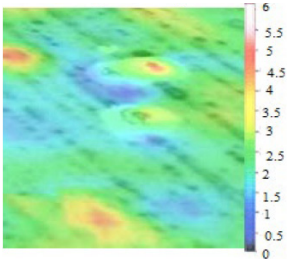
Presentation of research results

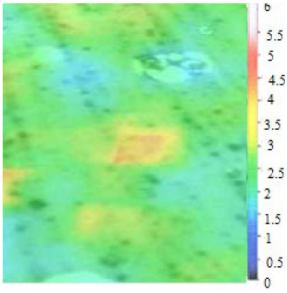
The surface topography of imprints on various materials was experimentally investigated. A change in the morphological structure of the substrate surface before and after printing was revealed. It was found that the presence of a chalked coating, which changes the parameters of roughness and the area of peaks and valleys on papers and cardboards, has a significant effect on the surface microgeometry (Table 3).

The analysis of tabular data and profilograms shows that the imprint on the cardboard is characterized by a large degree of unevenness, an uneven

distribution of surface structure elements, which is confirmed by the roughness parameter Ra = 0.43 μm, which indicates a highly developed micro- and sub-microstructure of the surface. Therefore, the conducted studies confirm that investigated imprints have different microgeometry of the surface.

Table 3. Results of studies of the morphology of substrate surfaces and imprints on them

Substrate	Weight, g/m^2	The nature of the surface	R_a, μm	Rz, μm	S_{peaks}, μm^2	$S_{valleys}$, μm^2
Paper UPM Digi Color	300	 Not printed	0,74	5,72	892	802
Paper UPM Digi Color	300	 Digital imprint	0,65	5,94	904	786
Tissue paper	80	 Not printed	0,48	4,64	686	712

Sub-strate	Weight, g/m^2	The nature of the surface	R_a, μm	Rz, μm	S_{peaks}, μm^2	$S_{valleys}$, μm^2
Tissue paper	80	 Flexographic imprint	0,32	5,86	748	648

The values of L* a* and b* measured for the colour gamut and the value of print chrominance are shown in Fig. 2 below. We can see the difference in colour transfer between different types of printing with the regulated colour coordinate according to ISO 12647. The wider the colour gamut, the greater the value of L* a* and b*.

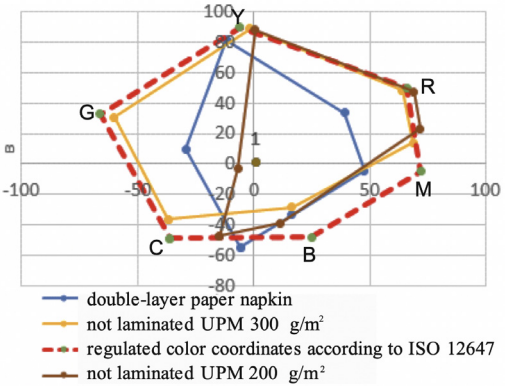


Fig. 2. Correlation of colour characteristics of studied imprints

Fig. 3 shows the values of the colour difference of CMYK, determined on the test scale (80%).

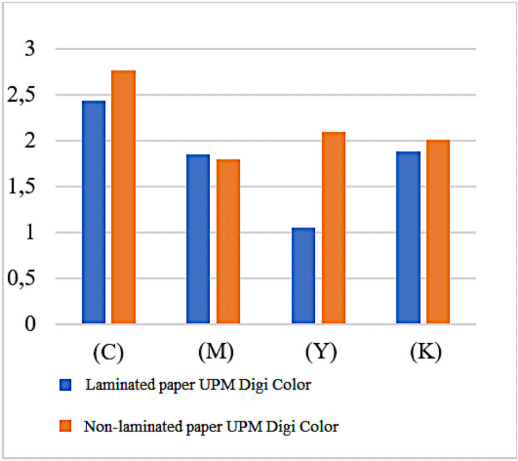


Fig. 3. CMYK colour difference diagram of digital prints

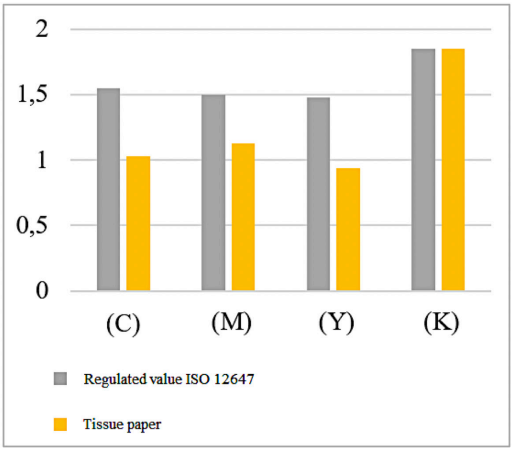


Fig. 4. CMYK colour difference diagram of flexographic imprints on tissue paper

As the research results show, the values of the colour difference of imprints on tissue paper, formed with contour ink, coincide with the standard ones. Deviations of 15–25% from the standard values have imprints of other CMY colours, which are placed in the Yellow > Cyan > Magenta range.

Conclusions

1. The structure of the surface of the unprinted material is repeated on the investigated digital imprints.

2. The topography of the substrate surface affects the quality of the formed images, as evidenced by the values of the optical and colorimetric indicators of imprints.

3. Lamination affects the quality of imprints, in particular, reduces their colorimetric indicators.

4. Flexographic printing on tissue papers reproduces tonal images differently for CMYK colours

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CHALLENGES AND OPPORTUNITIES FOR THE DEVELOPMENT OF THE GRAPHIC AND DIGITAL MEDIA STUDIES IN LITHUANIA

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Abstract

The graphic and digital media industry plays an important role in Lithuania and abroad, yet it inevitably faces a lack of specialists in this field. The shortage of professionals in the sector leads to the slower growth of businesses and industry, the lower value of GDP, and, in many cases, unskilled work, poor quality and inadequate presentation of information through different media. These challenges can be attributed to shortcomings of the Lithuanian higher education system. According to the Lithuanian Qualifications Framework, levels 5 (short cycle), 6 (bachelor's), 7 (master's), and 8 (doctoral) are classified as tertiary studies. In Lithuania, short-cycle studies in the media industry sector are still not available as the main focus is on the training of bachelor's and master's degree specialists.

The article analyses and presents the peculiarities of the Lithuanian education system, competencies, and acquired qualifications in different levels of studies. During the research, Lithuanian higher education institutions were compared, such as universities and colleges – higher education institutions (kolegijos in Lithuanian), which provide study programmes in different field related to the media industry. In addition, the role and potential of vocational schools in training media technology specialists is presented.

The results of the research show that the role of the Lithuanian education system is vital for the media industry. However, the potential is underexploited due to poor students' career guidance, lack of specific practical skills, or the worsening demographic situation in the country. The significant shortage of specialists can be related to the global pandemic, which had a negative impact on the learning process and, at the same time, forced the search for new teaching methods and tools. The analysis of the education sector's capacities to ensure smooth, rapid, and efficient training of specialists suggests that more emphasis should be placed on the training of media specialists in the narrow field within a relatively short period time. Such a study concept can be implemented in short-cycle studies when a specialist in specific media is trained through the synergy of a

higher education institution and an industrial enterprise within a year and half or two years.
Keywords: *education, media industry, competence structures.*

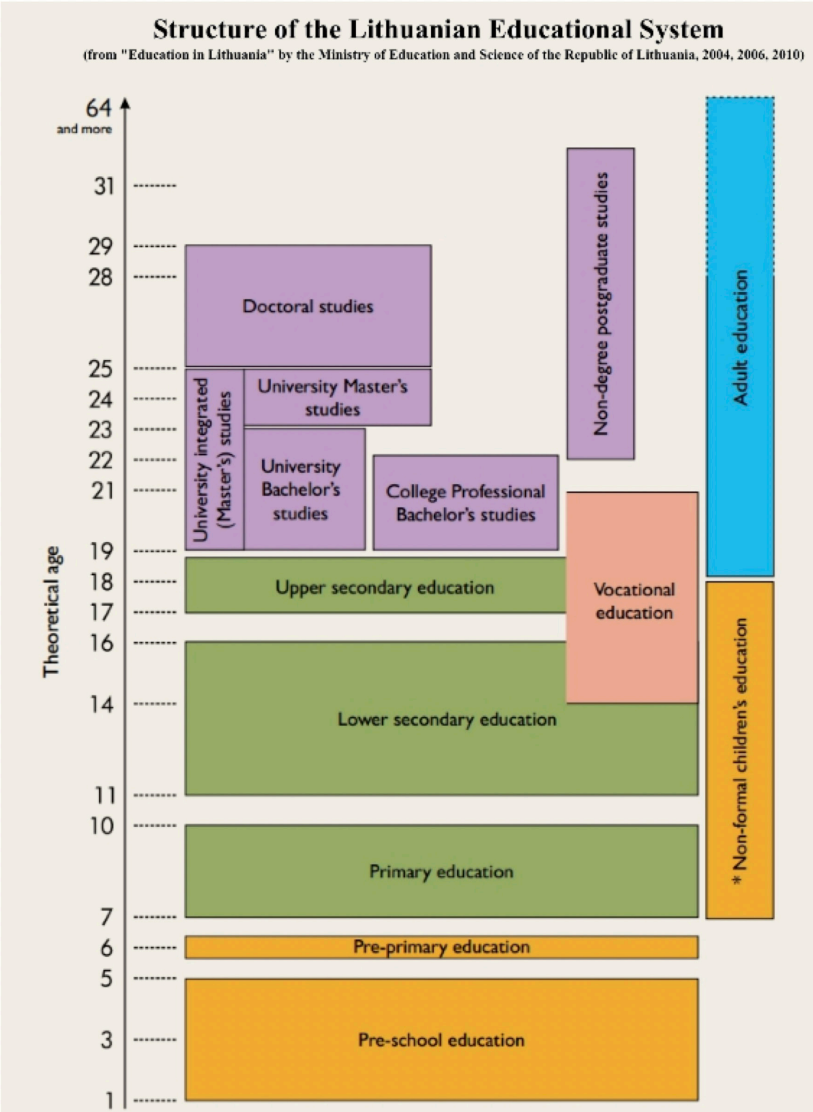
Introduction

Over the last decade, from 2010 to 2019, the rapid growth of 61.5 percent Gross Domestic Product (GDP) in Lithuania is directly related to the successful development of the business, industry, and service sectors (EUROSTAT, 2022). Thus, one of the key factors for a prosperous and high-added value business and industrial sector is qualified professionals. Despite the positive shift in GDP, the demographic situation in Lithuania changed negatively in the past decade, from 2010 to 2021, the number of inhabitants in Lithuania decreased from 3.29 to 2.81 million (Statistics of Lithuania, 2022). These factors led to a negative dependence between the number of specialists and graduates needed in the labour market: as the demand for qualified specialists increased, the population and the number of pupils, students, and graduates declined, accordingly (Želvys et al., 2021).

To meet the needs of the country's labour market, the Lithuanian education system is based on 8 different levels of education (Fig. 1.). Evaluating the training of qualified specialists, vocational training is well developed in the country and the duration of studies ranges from one to three years. Such training is classified as level 4 and the training is provided in vocational schools.

In analysing higher education, a binary system is applied, where bachelor's (level 6) studies are delivered by HEI colleges and universities, and the studies usually take three (180 ECTS) and four (240 ECTS) years, respectively. Meanwhile, master's (level 7) and doctoral (level 8) studies are offered by universities. Since 2022, short-cycle (level 5) studies have been launched in the country. Such studies will be carried out by colleges separately or in cooperation with vocational schools. The expected duration of studies is from one and a half to two years, or from 90 to 120 ECTS, respectively.

During the research, change in the number of pupils and students over the past 20 years, as well as the country's economic situation, was analysed. The article presents the offer of graphic and digital media study programmes in the country's formal education sector and the choice of the study programmes at the Kauno Kolegija HEI, as well as challenges and opportunities.



** Education can be conducted under pre-school and pre-primary education programme, but is not systemic*

Fig. 1. Structure of the Lithuanian Educational System (https://educationpolicytalk.com)

Methodology and material

The analysis of indicators is based on the data from official websites e.g. Eurostat, Lithuanian Statistics, AIKOS (Open Information, Counselling and Guidance Systems of the Centre of Information Technologies of Education), individual research, and studies carried out by other researchers. The data analysis covers the period 2000–2021 as follows:

- Number of graduates;
- Number of students;
- Number of vocational school students;
- Study programmes in progress;
- Number of the country's population;
- Other parameters.

Results and discussion

Education in Lithuania

The significantly declining number of schoolchildren and students was largely determined by the change in the demographic situation observed in the last decade, as the population in Lithuania decreased by almost 500 thousand. Meanwhile, over the past 20 years, the population has declined even further from 3.5 to 2.8 million. As a result, the number of pupils in general education schools decreased from 416 to 330 thousand (Fig. 2).

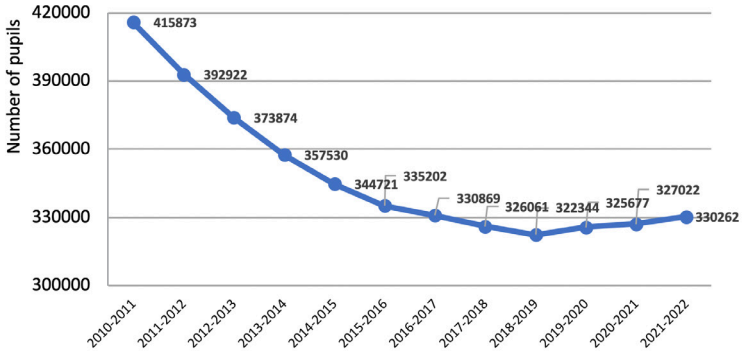


Fig. 2. Number of pupils in secondary schools (Statistics Lithuania, 2022)

The decreasing number of students was determined by different factors, such as the low birth rate of the population, emigration, and economic factors. However, in terms of the improvement of the country's economic situation and the return of migrants to the country, the number of students has slightly increased since 2018.

Negative trends in the number of students in Lithuania inevitably affected the number of high school graduates. Figure 3 shows the number of individuals studying at different levels after secondary school. Vocational training has witnessed a decline from 13,700 to 9,000 students, or 34 percent, over the past decade. Meanwhile, the number of undergraduate students (level 6) decreased from 150 to 74 thousand or 51 percent in the corresponding period. The number of individuals pursuing master's and doctoral degrees decreased, but not so drastically, from 21 and 11 percent, respectively. Taking into account these figures, it can be concluded that the largest number of students – more than half – decreased in bachelor's study programmes. The main reasons for this could be not only the above-mentioned factors but also a wider range of study programmes in foreign higher education institutions, volunteering, and better-paid jobs after graduation (Bankauskiene et al., 2019). The smaller decrease observed in the total number of students in master's and doctoral studies is explained by the fact that these studies are chosen by more motivated and high-achieving school graduates, the percentage of which remains relatively similar. In addition, the stability of the number of doctoral students could be affected by additional funding like scholarships.

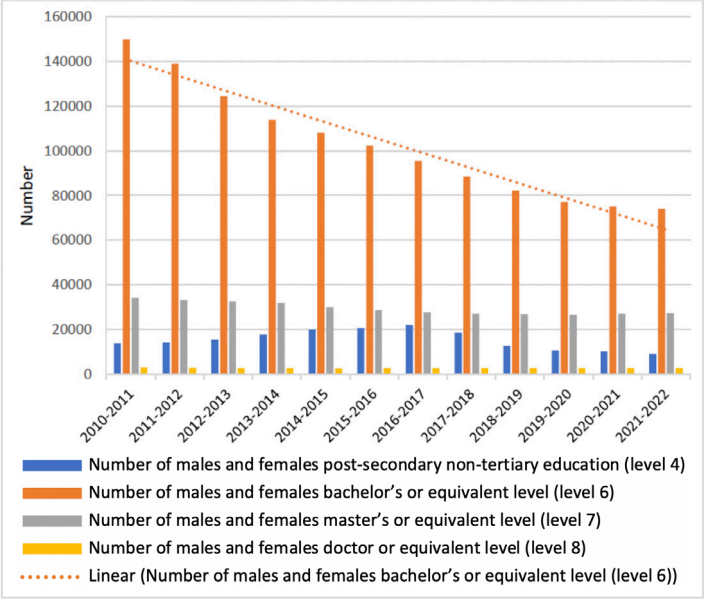


Fig. 3. Number of pupils and students by levels of education in Lithuania 2010–2022 (Statistics Lithuania, 2022)

Figure 4 presents students who completed different programmes in vocational schools. The programmes are divided into vocational training programmes for lower and upper and secondary education. The total number of vocational school graduates declined by more than 35 percent in the last twenty years. However, despite the overall decrease in the number of graduates, there was a noticeable positive change in the period 2010–2018.

This change is associated with graduates who acquired vocational education after high school in the last twenty years, when the number of students who obtained a secondary education and chose vocational training increased by 52 percent, whereas in the period 2010–2018, by 55 percent. This is directly related to the need for lower-level specialists and additional economic incentives in vocational schools. Comparing the number of students who graduated from vocational schools according to educational programmes with those without basic education, and the number of the students who completed educational programs with basic education decreased six times and in the last twenty years more than twice, accordingly. The considerable decrease in the number of students who graduated from vocational schools without a basic education is associated with the improved monitoring of the education system, quality assurance, and the need for higher competencies. The same can be said about students who graduated from vocational schools with a basic education when the significant negative change in graduates is associated not only with the decreasing number of students but also with the need for higher-level competencies (Bankauskiene et al., 2020; Zelvys et al., 2020).

The number of students studying in higher education institutions (universities and HEI colleges) is directly related to the number of students who have graduated from secondary school. In the period 2001–2021, the number of students who obtained secondary education decreased by 35 percent, and in the period 2011–2021 by even 48 percent. In comparison, the number of graduates in universities of applied sciences decreased by 43 percent and in four-year universities by 58 percent (Figure 5).

The significant decrease in the number of students who have obtained secondary education can be directly linked to the country's decreasing population, studies abroad, or emigration. The negative change in the number of graduates of higher education is associated with the number of students who have obtained secondary education. However, in the last decade, fewer and fewer school leavers have tended to choose to study at universities, and the number of students at HEI colleges has decreased, but not as significantly as at universities. As a result, a similar number of students graduated from HEI colleges and universities in 2021. This can be explained by the fact that

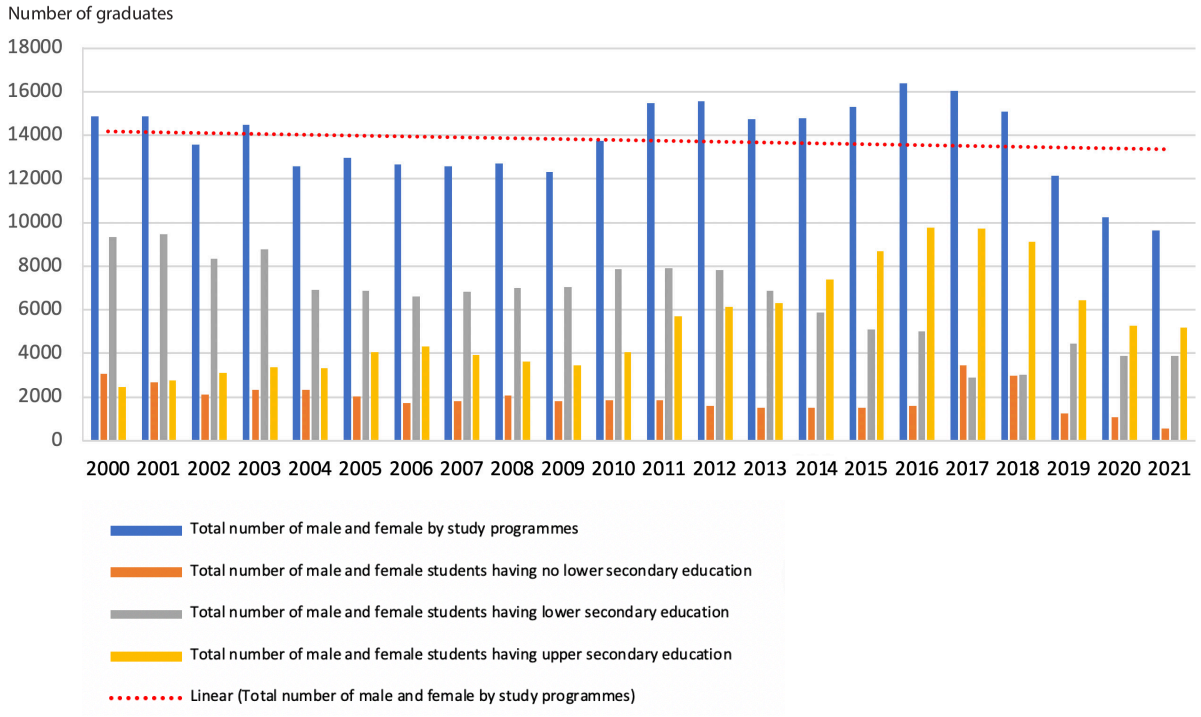


Fig. 4. Graduates of vocational training institutions in Lithuania 2000–2021 (Statistics Lithuania, 2022)

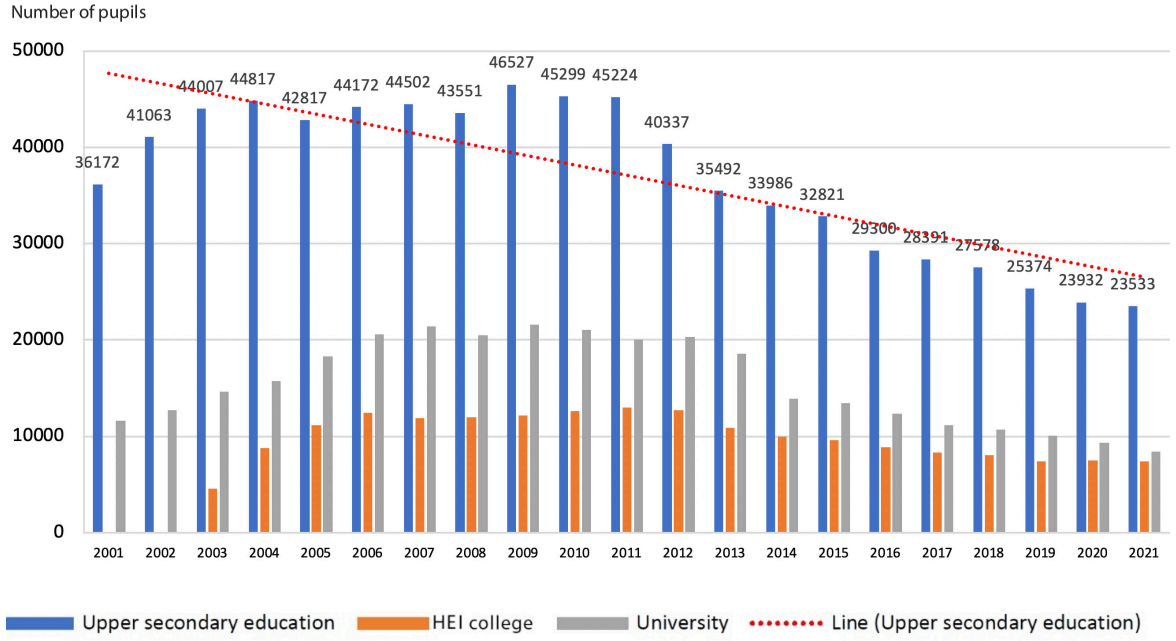


Fig. 5. Number of pupils and students who acquired education in 2001–2021 (Statistics Lithuania, 2022)

studies at HEI colleges are more appealing due to the shorter study period and practical activities.

Studies of graphic and digital media

The branch of graphic and digital media can be described as a broad and diverse sector covering technology, communication, design, journalism, etc. As a result, study programs related to graphic and digital media in Lithuania belong to different study fields: materials technologies, informatics, informatics engineering, programme systems, communication and media arts (Table 1).

Table 1. Study programmes related to the graphic and digital media sector in Lithuania (https://www.aikos.smm.lt/en)

No	Title	Study field	Degree	Duration	Mode	Institution
1	Multimedia and Internet Technologies	Informatics	Bachelor	4	Full-time	Vytautas Magnus University
2	Multimedia design	Informatics engineering	Bachelor	4	Full-time	Vilnius Gediminas Technical University (VILNIUS TECH)
3	Multimedia design	Informatics engineering	Bachelor	6	Part-time	Vilnius Gediminas Technical University (VILNIUS TECH)
4	Multimedia Technology	Informatics engineering	Professional bachelor	3	Full-time	*Kauno kolegija* HEI
5	Multimedia Technologies	Informatics engineering	Bachelor	4	Full-time	Kaunas University of Technology
6	Multimedia Technologies	Informatics engineering	Professional bachelor	3	Full-time	*Siauliu kolegija* HEI
7	Programming and Multimedia	Programme systems	Professional bachelor	3	Full-time	*Kolegija* of Social Sciences HEI
8	Programming and Multimedia	Programme systems	Professional bachelor	4	Part-time	*Kolegija* of Social Sciences HEI
9	Multimedia Design	Media art	Professional bachelor	3	Full-time	*Vilnius kolegija* of Technologies and Design HEI

No	Title	Study field	Degree	Duration	Mode	Institution
10	Video Production and Media	Media art	Professional bachelor	3	Full-time	*Kolegija* of Social Sciences HEI
11	Communication and creative technologies	Communication	Master	2	Part-time	Mykolas Romeris University
12	Creative Industries	Communication	Bachelor	4	Full-time	Vytautas
13	Creative Industries	Communication	Bachelor	4	Full-time	Vilnius Gediminas Technical University (VILNIUS TECH)
14	Creative Industries	Communication	Bachelor	5,5	Part-time	Vilnius Gediminas Technical University (VILNIUS TECH)
15	Creative Industries	Communication	Master	2	Full-time	Vytautas Magnus University
16	Creative and Entertainment Industries	Communication	Bachelor	3	Full-time	*Kolegija* of Social Sciences HEI
17	Creative and Entertainment Industries	Communication	Bachelor	4	Part-time	*Kolegija* of Social Sciences HEI
18	Creative communication	Communication	Bachelor	4	Full-time	Vilnius University
19	Communication of Creative Society	Communication	Master	2	Full-time	Vilnius Gediminas Technical University (VILNIUS TECH)
20	Creative Industries Technologies	Material technologies	Professional bachelor	3	Full-time	*Kauno kolegija* HEI

20 study programmes, either bachelor or master's study programmes, related to graphic and digital media are implemented in the Lithuanian higher education institutions. Most of them are carried out in level 6 – professional bachelor and bachelor studies. Meanwhile, in level 7 there are 3 study programmes (master's studies). Level 6 full-time studies last from 3 to 4 years,

extended studies from 4 to 6 years, which in turn, make the studies unattractive to students and the labour market. Master's degree studies last for 2 years. Although a significant number of study programmes is implemented in the country's higher education institutions, many of them are focused on informatics or communication sciences (Sajek, 2019). Meanwhile, the number of study programmes implemented in the field of materials technology studies is minimal.

The graphic media study programmes implemented at the Kauno kolegija HEI are presented in Figure 6: Graphic and digital media, Advertising Technologies (from 2022 – Creative Industries Technologies), and Multimedia Technology. All programmes are carried out in the 1st cycle of higher education (professional bachelor's) studies.

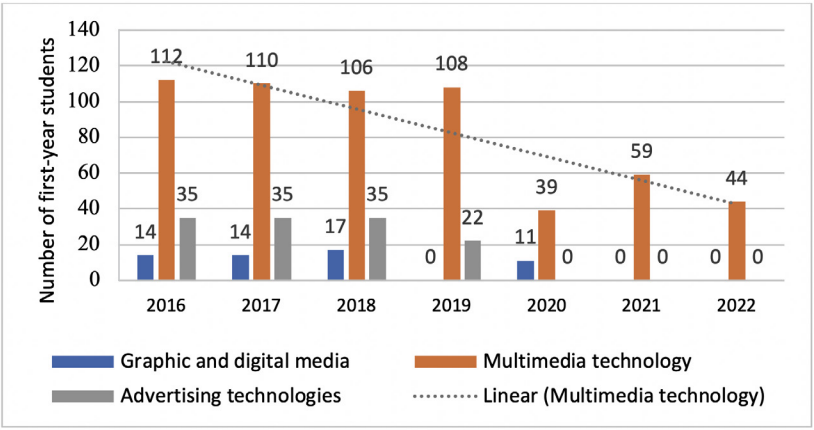


Fig. 6. Distribution of first-year students by different study programmes at Kauno kolegija HEI

Analysing the number of first-year students in the study programmes from 2016 to 2022, it is evident that the number of students decreased sharply. The number of first-year students in study programmes like Graphic and digital media fell from 14 to 11, Advertising technologies from 35 to 22, and Multimedia technology from 112 to 44. The negative change in the number of students is associated with the decreasing number of students who obtained secondary education, the large offer of study programs in Lithuania and abroad, and the popularity and trends of study programmes.

Discussion

Over the past twenty years, there have been noticeable signs of a change in the demographic situation, when the population in Lithuania has decreased significantly. This is directly linked to the reduction in the number of pupils who completed primary and secondary education, and, in turn, graduates from vocational and higher education. There is a clear trend that in the last decade, more and more students have chosen to study in vocational schools after obtaining secondary education (Zemaitaityte, 2016). Meanwhile, fewer and fewer students chose higher education studies, which led to a significantly lower number of graduates. This change was mostly observed in universities, which faced almost a twofold reduction in the number of graduates. It was also noticed that the number of school graduates applying to three-year HEI colleges is similar to the number of applicants to four-year universities, which means that future students will choose shorter and more practice-oriented studies. Given the economic indicators in Lithuania, there has been noticed a significant change since 2000, when the gross domestic product doubled and even outpaced the average of the European Union (Eurostat, 2021). This shows that the part of the industry generating high-added value has grown considerably, which inevitably affects the demand for highly-skilled professionals in the labour market. In the case of a negative ration between the graduate supply and the demand for specialists in the country, short-cycle higher education studies, non-formal education, and other ways are proposed to address the existing challenges (Zuzeviciute et al., 2017; Zelvys et al., 2020).

Conclusions

Negative demographic changes in the population in Lithuania over the past decade have had a direct impact on the number of students in the country. The biggest fluctuation in the education system is observed in the training of qualified specialists, at level 6, bachelor's studies. Meanwhile, the change was not so significant in the number of students studying at levels 4, 7, and 8 – vocational training, master and doctoral studies. These negative changes are associated with a wide choice of study programmes in Lithuanian and foreign higher education institutions, emigration and demographic factors, and the ongoing reforms in the higher education system.

Over the last decade, the training of specialists in vocational schools was mainly focused on the acquisition of specialty after obtaining secondary education. There was also a noticeable decrease in the number of students choosing vocational training after obtaining lower secondary education. The increased popularity of post-secondary vocational training is associated with economic incentives, meeting the need for industry and business.

Twenty bachelor and master's degree study programmes related to the graphic and digital media sector are implemented in the country's higher education institutions. However, the majority of study programmes are delivered in the study fields of communication and computer sciences. For these reasons, there is a shortage of graphic technology specialists in the country.

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SHAPING THE EUROPEAN FUTURE WITH BOOKS (FACTS AND THOUGHTS REGARDING A CONFERENCE)

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Abstract
The authors – who have been working in the world of printed books for decades – tried to formulate the challenges and trends that characterize the future coexistence of European people with printed books by analyzing recently published scientific publications, conference presentations and expert reports.
Keywords: *Future of print, book production, publishing, book market trends, sustainability.*

1. Introduction

The Óbuda University and Alfoldi Printing House, which is considered iconic in Hungary – with a history of more than 460 years – are conducting joint research, the aim of which is to explore the expectations of the young generation who use textbooks in relation to printed communication. How the design and production of textbooks should be adapted to these expectations.

The authors – as part of this scientific program – summarize and analyze the expected trends in the world of books, which will also be the key driving forces of the book market and book production: lifestyle and habit changes characteristic of the period of the Covid-19 epidemic; issues of sustainability, the rise of digital printing, the ever-widening use of electronic end-user products, and the exploding costs of production.

2. Methodology

The authors participated in the conference organized by INTEGRAF (the European printing industry association) in 2021, which focused on the future of printed books.

"Shaping the Future with Books" conference was an event with two chapters. Chapter 1 was a webinar in February 2021 which gave an overview of the latest market research, as well as expert views on the status of the book industry from the perspectives of a printer and a publisher. Chapter

2 was organized in October 2021, as an "in person" conference at the Frankfurt Book Fair, in Germany. The keynote speaker was Intergraf's research partner Smithers, who presented their market data and recommendations, prepared exclusively for this event.

The authors summarized the following facts and thoughts from the conference presentations, supplemented with conclusions from other scientific publications and their own research results within the given framework of this paper.

3. European printed book market

Whilst the book printing market in Europe has faced challenges from falling readership and greater costs within the supply chain which are driving a decline in number of physical books being printed, the output in terms of revenue are expected to grow from 2020 onwards predominantly due to the increasing adoption of digital printing processes.

COVID-19 caused the most dramatic change to the market since the crisis in 2008. The pandemic's most immediate influence was on supply chains throughout the book printing market, many printers could not work at full capacity as well as many suppliers were restricted by regulations especially in regards to crossing country borders. As a result, 2019 the total European market was valued at €6.32 billion, which saw a decline of 8% in just one year in 2020.

Through the 2021–2026 period, book printing revenues are set to increase by 29% in current terms (17% in constant terms) in Western Europe. Central & Eastern Europe book printing revenues is also expected to rise by 27% in current terms (10% constant terms) during this five-year period.

On the Figure 1 the constant price values show market data at 2020 prices, removing impact of inflation and exchange rate fluctuations from one year to the next.

As eluded to previously, despite the projected increase in revenue the output volume is on a downward trajectory, and has been since 2008.The decline in printing output by '000 tonnes has been regular since 2015 barring a more dramatic drop of 10% between 2019 and 2020. Following the pandemic, the output by volume is expected to return to a more reasonable decrease at –2% CAGR between 2020 and 2026 (Figure 2).

The most common book printing process employed by book printing today is offset lithography; this includes three main variations, sheetfed, heatset (web), and coldest (web). Digital print is becoming more popular with a focused trend towards inkjet. Other processes include flexo, gravure, and letterpress.

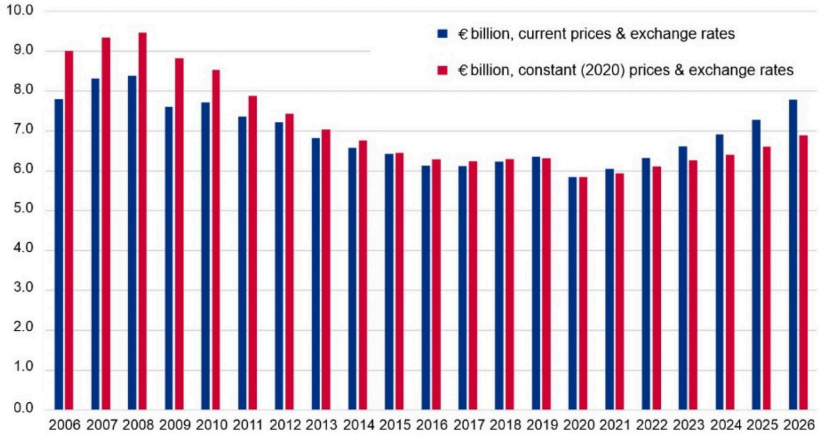

Fig. 1: European Book Printing Output, 2006–2026
(Source: Smithers,2021)

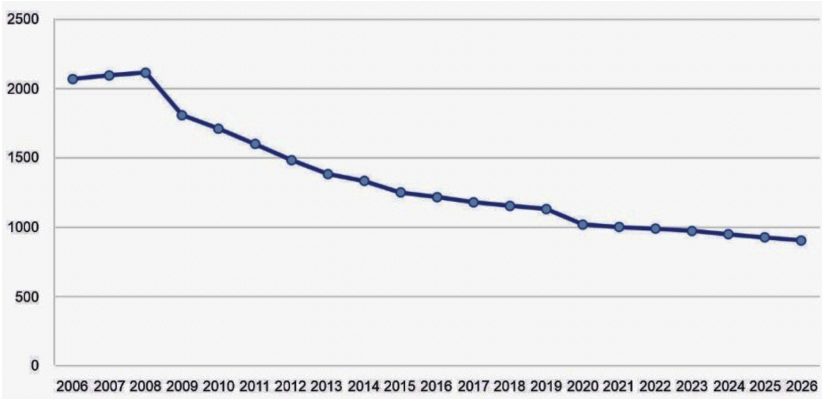

Figure 2: European Book Printing Output, 2016–2026 (‘000 tons)
(Source: Smithers)

Sheetfed offset has traditionally been used for shorter runs and high-quality printed books, with applications including covers, book jackets and colour sections for many books, with specialist large format perfecting book presses widely used to print short to medium runs. This sector received a boost with the arrival of size VI (1.0m x 1.4m) large format colour perfectors with high levels of automation to make fast-changeover, full-colour book printing more efficient. Sheetfed book volumes are falling though, as more efficient alternatives are used.

Coldset book printing remains very significant, employed across a range of diaries, religious, educational and trade fiction titles – both hardback and softback. Heatset is used to print long-run colour books; many book presses have heatset ovens that can be used for colour and switched off when the press is producing mono titles (often using two webs).

Electrophotography first made its mark in book printing back in the 1990s with the Xerox Docutech making short-run mono books economic. It gradually increased share with continuous presses offering an alternative to litho, opening up print-on demand and long-tail operations and keeping more titles in print. It also opened up new opportunities, with self- publishing becoming a significant sector and some book printers offering author support with web-to-print to take files into templates, and providing services such as obtaining ISBN details, etc. Colour electrophotography is now increasingly used to print colour sections – particularly covers – as an alternative to sheetfed.

High-volume inkjet is being rapidly adopted by book printers across the world as supply chains develop to print smaller batches quickly and economically. High-speed inkjet presses, linked to sophisticated slitting, cutting and folding finishing systems, are now allowing the economic production of mono and colour titles, either as book blocks or folded sections. The economic crossover (where litho cost is lower than inkjet) is approaching a run of 10,000 for mono and in the thousands for colour titles. The combination of high-volume printing with highly automated finishing has changed the economics and response times for book production and consequently traditional publishing supply chains.

The printing output of all three lithography processes is still greater than digital in terms of revenue (by current price). Yet over the next five years, Inkjet is projected to grow by 125% between 2021 and 2026, which will see it overtake the combined analogue print processes (Figure 3). However, in terms of volume of printed books, analogue processes will remain collectively greater than that of Inkjet. Whilst every other printing process is declining in output, Inkjet is the only process seeing any market gain, even

with the growth of Inkjet the European book printing market as a whole is dropping by 7% from 2021-2026 (million A4 prints) (figure 4).

"Inkjet is changing this market" (Thomas Poetz, Smithers)

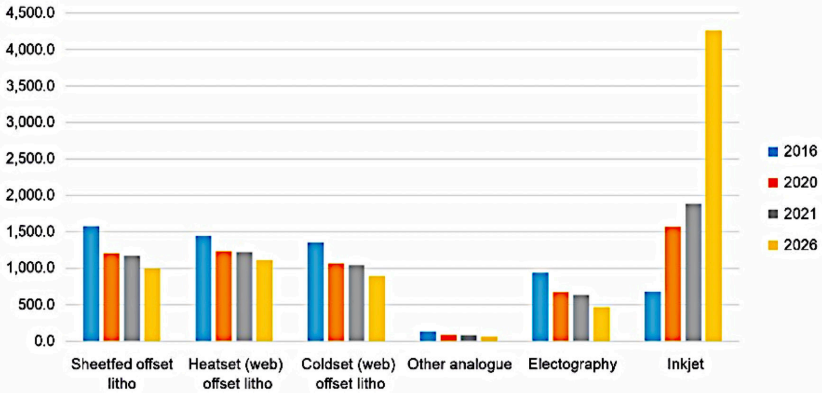

Figure 3: European Book Printing Output by Process
(€ million, current prices and exchange rates)
(Source: Smithers, 2021)

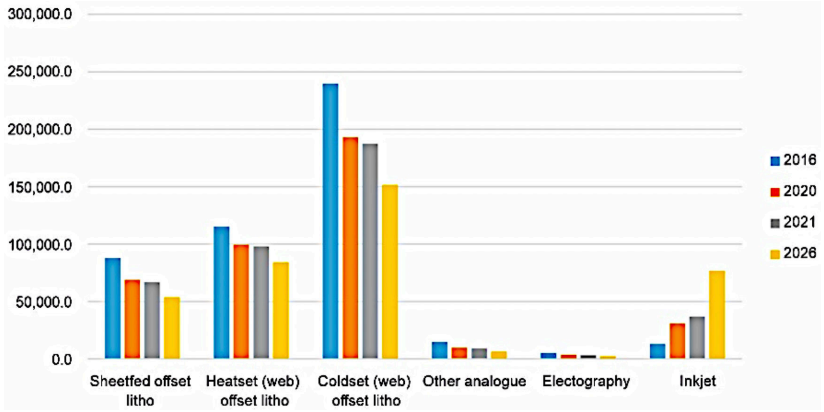

Figure 4: European Book Printing Output by Process, 2016–2026
(Million A4 Prints or equivalent)
(Source: Smithers, 2021)

4. Key drivers and trends

Over the last few years, there have been a number of significant factors impacting on the book printing industry, some of which have immediate short-term effects, whilst others will have major impacts in the long-term. COVID-19 has been the most significant factor, but most of the initial changes will likely only be short lived. Whilst the development of higher quality digital printing methods will lead to a more long-term change to the industry. Other trends including changing production methods to compensation for the increase in costs, and the growing demand for sustainable practices from an ever more aware consumer market, will force production to adapt (Mureau – Wells, 2018).

One trend that may not affect the market as expected is the changes to a digital platform, with the e-books market seemingly stagnating.

4.1. Sustainability … *is not a trend anymore, it is real business*

Climate change is one of the biggest topics in the modern era with a huge emphasis being put on environmentally friendly actions for people, companies, and countries. This topic is at the forefront for many consumers and will often influence their feelings towards a company and its products. This mind-set from the public has put pressure on, governments and unions, as well as businesses, to promote sustainable practices.

The paper industry is already one of the most sustainable in the world, unfortunately, the industry has somehow gained something of a bad reputation when it comes to sustainability. There has even been schemes to try to limit paper usage by consumers even though managed forests, which are the greatest suppliers of pulp for paper, are often carbon neutral in their efforts. Despite this, companies within the paper supply chain have made a move to be even more socially responsible.

This move to sustainability is highlighted by some of the largest publishers' devotion to a sustainable approach, with their aims to make a positive social and environmental impact. This plan is based on three pillars: learning for everyone, learning for a better world, and leading responsibly.

Printers must increasingly prove their credentials by providing clear emissions data about their products. 'Intergraf recommendation on CO_2 emissions calculation in the printing industry', was published in 2013. This recommendation was the only international graphic standard for carbon calculation in the world, designed to ensure that everyone who uses it calculates on the same basis (ISO 16759:2013).

Reducing waste/over-printing is important: "it would make a big difference if we could get the right books to the right people" (Michiel Kolman, Elsevier)

4.2. Consumer trends … *social media is stealing time from consumers to read books*

Reading is a very environmentally-friendly activity – be it in the physical or digital world.

Retail is not physical vs. online, it is omnichannel

„Print has a strong value proposition for consumers", with price not even in the top five selection criteria of where and why one buys a book. This led to the conclusion that "a beautifully printed book remains important even in an omnichannel market". (Andre Breedt, Nielsen Book)

How do 15-year-olds read in today's world?

37% of students rarely or never read books; 36% read books more often in paper format; 15% read books more often in digital format; and 12% read books equally often in paper or digital format. (Miyako Ikeda, OECD)

When comparing between different kinds of readers, the OECD found that "in high-performing education systems more students tend to read books more often in paper format", while "in low-performing education systems more students tend to read books more often using digital devices".

Consumer behavior perspective

As society changes, so does its reading practices. But it is clear, that printed books remain an important part of this conversation. Book volumes in all formats (print and digital) are growing, with certain genres lending themselves more to certain formats and all co-existing in a diverse marketplace. There are some concerning trends, such as the decreasing rate of young adults reading books (in any format) and the growing socio-economic gap between those who read and those who do not. However, reading – be it for pleasure, information, or learning – remains a popular activity that is given importance.

Traditional printed media is much more effective when it comes to memory recall and the retrieval of information" compared with digital media. (Olga Munroe, Leeds Beckett University)

4.3. Book-production … *is a changing world*

COVID-19 has undoubtedly had the greatest immediate impact on all industries in recent years, especially during 2020, resulting in a reduction of output by volume and revenue. Pandemic has acted as a time machine, accelerating the trends that were already in motion. It quickened the consumer jump from printed educational and academic books to electronic substitutes. As well as speeding up them production methods change to shorter run prints and digital processes.

Many printing companies shifting towards a print on demand (POD) business model, the industry's commitment to automation is increasing.

These developments reflect recent changes in consumer behavior, which are "changing the market". Consumers now expect personalized and individual products, easy and fast online ordering and delivery, and a greater emphasis on eco-friendly products with longevity (Horvath et all, 2018).

Consumers are increasingly 'glued' to their screens, with the more intelligent our mobile devices become, the more antiquated the humble book seems. Streaming services are becoming ever more popular and taking up an increasing size of the entertainment industry, and the ever-present entertainment formats such as TV and Video gaming, these together are squeezing the space available for other forms of entertainment such as books.

Not only are the products themselves being digitized, but also the methods of procuring said items have become increasingly digital. E-commerce has been continually growing over the years, especially in conjunction with the powerhouse Amazon.

The cost to produce printed books in Europe is increasing, this has been caused by a multitude of reasons. One factor influencing production cost rises is the desire for quick turn around on printed books, wholesalers and retailers do not want to hold high levels of stock and instead they are putting pressure on printers to produce smaller volumes of a larger range of titles. Another factor being the increase to transportation of products, it is becoming increasingly costly to distribute final products, the cost of shipping and lorry hauls have increased, largely due to the logistical issues set about by COVID-19, on top of this there is currently a driver shortage.

Prizes of graphic papers have been dramatically rising.

The future is digital, in more ways than one, from the production of books to the methods of purchasing and consuming product. The following is an example of the use of augmented reality (AR) in the world of printed books.

The purpose of the LibrAR mobile application developed by Alfoldi Nyomda is to extend and expand the information appearing in the book.

The camera of the mobile phone or tablet is pointed at the page of the book, and something else appears in the place of the image, e.g.: another image, an image gallery, animation, a 3D model that can be walked around virtually, a video, an audio file starts, but it is also possible, to launch the phone's navigation program and navigate to a specific geographic location, but we can even discover hidden content in a book through it. The special feature of the application is that there is no need to spoil the overall image of the book, for example by placing a QR code, only a well-recognizable image and a so-called marker are needed. Most images and graphics can be used as markers. All that is needed is that it contains sharp, contrasting angles. And the librAR corner mark printed on the corner of the image is just

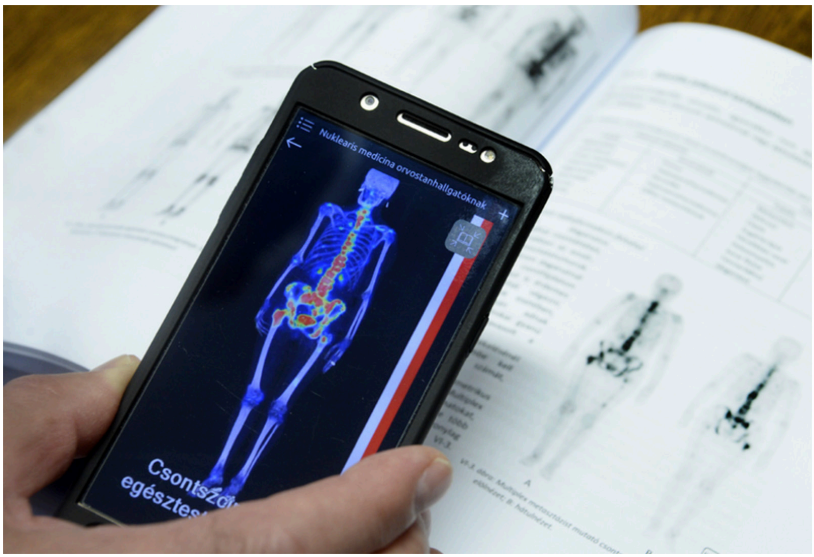

Figure 5: LibrAR application in use

to inform the reader: this image is more than meets the eye. The application of AR therefore opens new dimensions in the world of books and enables readers to have a much more interactive and enjoyable experience (Horvath et all, 2020).

Europe's book market is dynamic and mirrors similar trends in the wider graphical sector. For example, the growth of digital printing and shorter run lengths. Personalisation, special editions, print on-demand, and automation are all becoming more common, as is publishers' shift towards smaller stock models (reducing warehousing and waste). Moreover, the significant growth of inkjet is having an impact on book production.

There is also plenty of innovation in the sector to facilitate more competition with large companies like Amazon who dominate the market.

5. Conclusion and practical implications

Printed books have proven to be resilient in the face of digitization, even during a pandemic which accelerated the digital transition.

Common targets and actions can be formulated to European publishers and printers (Peter Kraus vom Cleef, FEP).

- "Work together to contribute to achieving the United Nations Sustainable Development Goals".

- "Improve our ecosystem together by thinking in networks and reducing our carbon footprint" – for example, by using more AI to "better forecast what we need to print".
- "Lobby together for our cultural and creative sector"

"Collect together all the research, studies and information about the benefits of reading – and particularly reading in print" – and publish it alongside other stakeholders like booksellers and librarians.

6. European book printing industry outlooks

The outlook for the European book printing industry is digital. Digital processes (specifically Inkjet) are likely to surpass analogue processes in terms of revenue as inkjet is expected to be the only process to see any growth over the next five years. On top of this digital media continues to cause physical books volume to decline. This has been seen with the reduction of education and academic books being substitute for e-learning methods. There are further digital impacts with competition from digitalised substitutes such e-books and audiobooks, along with digital entertainment such as TV, film, and gaming on the rise.

A key conclusion

Books was that books – both printed and digital – are an essential part of our daily lives. Printed books – in particular, remain popular and necessary because they continue to offer something different from digital versions. In this thriving market, there is space for different formats.

"There is something magical about the printed book" – in this market, there is room for all of us! (Vicky Ellis, Clays)

7. Acknowledgement

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THE TECHNOLOGY IS NOT THE PROBLEM, BUT THE PEOPLE

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Abstract

We actually in printing-industrie have almost everything we could wish for in terms of printing technology. We have the possibility to match the colours to a large extent beforehand and to print in such a quality that the customers are satisfied. Everything is actually there.

The problem, however, is the complexity of the solutions. Suppliers suggest the exact opposite of complexity. The common programmes that are used to create the PDF files that are then sent to the printers for printing, initially give the impression of being child's play to use. The graphic agencies, the largest group of customers of the printers, also think that everything is very simple. In the courses for graphic designers, printing technology is often not even taught as a separate subject. The idea prevails: "If the file looks good on the screen, my job is done!" That this is only about half the job, is known to anyone who has to rework PDF files in the graphic arts industry. And so we have the problem that from the outside everything in the printing industry is quite simple, almost trivial. But if we look more closely, the enormous choices in prepress and production, ultimately create an enormous complexity of all processes, that is difficult to oversee and deal with. Colour management, for example, requires very extensive knowledge. CIP3 cannot be mastered without in-depth IT knowledge. The temptation is to buy in the knowledge from suppliers. As a result, printers have equipment that has been set up once by suppliers and is then only to be operated in a comparatively mindless manner. The slightest error means that technicians have to be called in.

This article examines the real problems in the day-to-day work of printers, in opposite to the problems that manufacturers tell us are a problem. It gives principled suggestions on what should be changed in training, it formulates questions that responsible people in the printing industry should ask themselves. And finally he gives practical advice on what could be done differently in concrete terms.

Keywords: *printing industry, monopolies, open-source, higher education.*

Introduction

We actually in printing-industrie have everything we could wish for in terms of printing technology. We have a wonderful exchange format for our files, namely PDF. The files can not only contain the appearance of the printed matter, but they can even transport metadata of the jobs, such as the client's address, delivery address, print run, formats, deadlines, etc. We can check these files with relatively cheap tools and change them for our purposes: we can convert colours from RGB to CMYK, we can change resolutions, we can compress images, etc. We can also impose the individual pages we get onto large sheets with relatively cheap programs. We have presses that run very fast and we have other presses for which we don't even have to make a printing form. Every print can be different. We can even have our software talk to our presses via CIP3 or CIP4 so that the press already knows from the job data which format with which ink coverage is now coming its way. The cutting machine and the folding machine can also receive this data. We can even use ICC profiles to communicate colours securely across hardware and software boundaries. The software and hardware for all these nice things doesn't even cost an inordinate amount of money. All this technology is available, the standards are defined. Why is it that only in very few printing plants do the machines and the people work together as if by magic, harmoniously and without interference? Why do we still produce tons of waste? Why do we use software and hardware from quasi-monopolists even though we don't have to because of the open standards?

The title of my lecture is the answer to these questions: The problem is not technology, the problem is the people. Of course, this is a somewhat exaggerated title that is not quite right. Current technology is very complicated to understand and it is very complicated to use. I readily admit that. You can learn to understand these techniques, but it takes time and you really have to get involved. Accumulating superficial half-knowledge instead does more harm than good. At this point we are ultimately back to the statement that the problem is people. The knowledge of data structures within PDF. The knowledge about data structures in an ICC profile. Knowledge about XML or databases is frighteningly low and, in my experience, it tends to decrease over the years rather than increase. The right way out of this misery would be to improve education in vocational schools and higher education. This is not happening, at least not in Germany. At the design faculties I know of, there is no subject in which printing technology is specifically taught in its entirety. When I was still working at the Anhalt University of Applied Sciences at the Bauhaus Dessau, the students specially asked me to teach printmaking outside their prescribed lessons. They didn't get any marks for

it, but they saw that they needed this knowledge to act more easily in their professional lives. At universities, training in print technology only takes place in degree programmes that are explicitly called print technology. In graphic arts courses, some of this knowledge would be urgently needed, but this teaching simply does not take place. I hope that with this lecture I can contribute to changing this actually nonsensical state of affairs.

Here the improvement of the workflow through the use of CIP3/4 is shown:

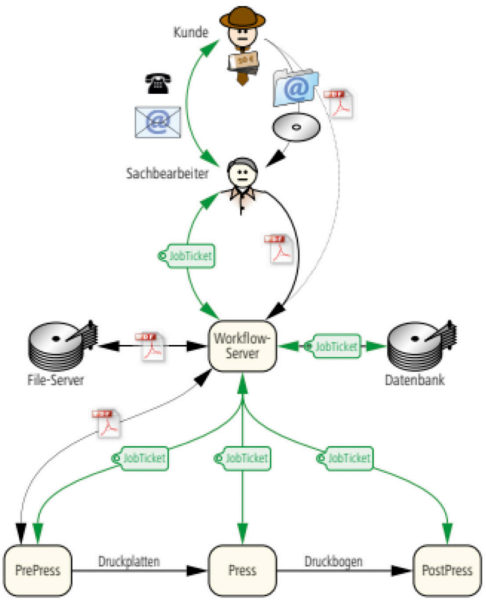


Fig 1. Workflow with CIP3/4

Methodology

I must apologise that it will not be a scientific lecture in the strict sense. I can only say many things from my experience and cannot prove them with statistical figures. Why can I claim that my statements are nevertheless relevant? I not only teach printing technology, but I also place many printing orders every year at the university and privately for associations. As head of the university print shop, I also get a lot of orders and have to process the incoming data. And finally, I talk a lot with printers and users about the jobs. For these reasons, I claim that my assertions go beyond a merely private opinion, even if they are not proved in a strictly scientific sense.

Presentation of research results (Analysis)

After all, everything works without the customers knowing what properties the print files must have! We have to ask honestly why exactly does it work?

First answer: I don't want to argue with a client and correct the file, which is usually quicker than asking the client back. I can do the corrections manually with Acrobat, or you can use tools like PDF Toolbox that do it automatically.

Second answer: PDF files created with the common programmes of a big American manufacturer work in most cases. So I recommend my clients to use the programmes of the big American manufacturer as well. In addition, I now know the common errors that occur when using the programmes of the big American manufacturer and have built appropriate change routines into my programmes.

Third answer: If, for example, the bleed is missing, I have no choice but to tell the customer that I need a new file. So I explain to the customer how to create a file with bleed in his programme. Sometimes I also have to explain what a bleed is and why it doesn't work without one. (Is there anyone here I have to explain this to now?) It can happen that I have to explain this to trained graphic designers.

Perhaps you are now asking, why is he getting so upset? After all, everything works fine without the customers knowing what properties the print files must have! We have to ask honestly why exactly does it work!

So the whole printing technology works without even the professional clients, who are often trained graphic designers, knowing exactly what data they have to supply. We, as printers suffer greatly from this with considerable extra work. And we are ourselves to blame for several reasons:

Firstly, we provide the training service in the feedback to the customers, for which would actually be responsible the universities or the training institutions. I realise that every printing company has to do this because otherwise the customers will go to a competitor. But it could also be, that the customers go to a competitor anyway with the knowledge that I have painstakingly imparted to them before.

Secondly, we limit ourselves, at least in Germany, to the programmes of a very big American manufacturer, because we assume that the files produced with them will work for us in most cases, even if the operators ultimately do not know what exactly they are doing. Whether this is only because we are accustomed to the mistakes made by the big American manufacturer, or whether there might be alternatives, is not asked. I have to admit that in the day-to-day business in the printing plants, there is too little time to try out alternatives.

Thirdly, in the printing plants there is also often only partial knowledge. They are happy if they can somehow get the print jobs through production without any complaints. The actual expert knowledge is often no longer to be found in the printing plants, but rather with the assemblers and in the customer service departments of the manufacturers. My call here would be, to get the basic knowledge back into the print shops. Of course it is tedious to work through a PDF reference manual with over 1000 pages, but afterwards you know exactly how a PDF file is structured and how you can change it. It becomes clear what the respective programmes in one's own print shop do with the files.

Fourthly: What is even worse is that as a print shop manager and lecturer I would certainly know alternative programmes to those of the big American manufacturer, but my professors from the graphics department forbid me to use them because supposedly "everyone" works with the programmes of the big American manufacturer and the students are supposed to be trained in a reality-based manner. In my experience, however, students who have really mastered alternative programmes can very quickly switch to the programmes of the big American manufacturer. I also remember very well when the common programmes used to be called PhotoShop, QuarkXpress and Freehand. The almost complete changeover to the current big American manufacturer happened in the printing industry in Germany within a period of three years. So you can change over if you really want to.

So let us summarise the four reasons why this system of professional incompetence nevertheless works:

- printers provide free educational services.
- graphic agencies and printers prefer a software manufacturer whose products usually deliver usable results even without specialist knowledge
- printers can ultimately only use the products of this big American manufacturer and often have little in-depth expertise themselves.
- because almost everyone lives in this incompetence bubble, even the few who know and master alternatives are tempted or even forced into incompetence.

This somewhat frustrating development is not even noticed in most cases. When I point out this undesirable development, as I have done in this lecture and on other occasions, many reasons are given as to why everything cannot be done differently. If I roughly summarise these reasons, then these are the reasons that I fear are the main reasons for almost everything in Germany only:

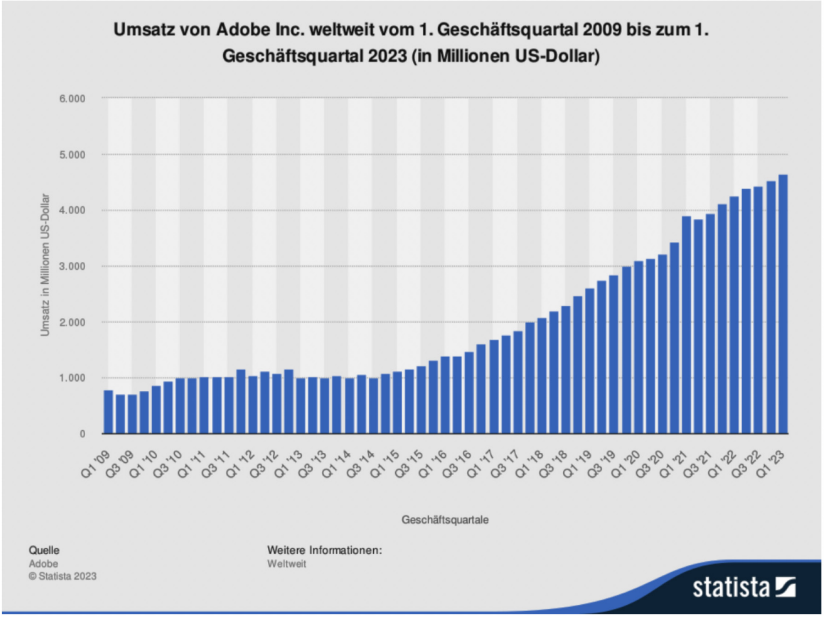
- we have always done it this way!

- we have never done it like this before!
- anyone could say anything!

I fear that there are similarly valid robust arguments in many countries.

Adobe Inc. worldwide revenue from 1st fiscal quarter 2009 to 1st fiscal quarter 2023 in US-Dollar millions:

Fig 2. Adobe Inc. worldwide revenue



The result is that we spend far too much money on not bad, but rather mediocre products. We even let ourselves be forced into a subscription model. You can clearly see in the graph that the big American manufacturer quadrupled its sales after introducing his subscription model. Even our faculty in Mittweida pays a lot of money and indirectly even advertises this monopoly. Similar subscription models are becoming more and more common, even among large printing press manufacturers. Knowledge is shifting more and more away from the users to the manufacturers. This is not only the fault of the manufacturers, but also the fault of those who let this happen to them.

Conclusions: What can we change?

It is really about education.

- all those connected to the printing industry should push for sufficient print technology to be included in the training courses for graphic designers.
- the problems would be solved if there were degree courses that taught print IT or IT for printing technology and were then also attended by many students. However, I fear that too few young people will be enthusiastic about this.

All those who train should always ask themselves the following questions:

- do I really understand what the software I use does?
- is there other software that does similar or better? Am I really able to work professionally with alternative software? Do I have the time?
- is there perhaps even open source software that does something comparable? What would have to be improved in the open source software in order to work with it more professionally? Who could finance this? Could we perhaps develop plug-ins in our faculty to improve OpenSource?
- in all my software and hardware decisions, do I make sure that everything works with open interfaces as much as possible? (For example: PDF, CIP3/4, database connection, ICC profiles).
- Is there hardware that does similar or better and is cheaper? Do I really give smaller companies a chance?
- am I prepared to think myself into my machines to such an extent that I can carry out minor repairs and maintenance work myself? Will the manufacturer even let me do that?

More practical conclusions:

1. LibreOffice instead of Microsoft programmes. For example, if you are doing a conference proceedings, almost everyone has a different version of Word. Unfortunately, the versions on Mac and PC differ and there is no Word at all for Linux. If you then have to combine several documents into one, there are often terrible problems. That's why I usually converted everything in LibreOffice for such projects, fixed the format errors and then combined them into one document. Also, vector graphics can be embedded and output well throughout LibreOffice as SVG graphics. Word can only do EMF and WMF, which can lead to very strange effects with fonts. Only Word for Mac can really embed PDF.

2 Scribus, VivaDesigner, Affinity Publisher instead of InDesign. Admittedly, Scribus is much more difficult to use than InDesign and it is also less comfortable. But it has two big advantages: firstly, it is free and secondly, the source code is open so that you can program your own extensions or commission them easily. It is also interesting to see the sales development of a big American manufacturer, especially since it has only been selling its software on a subscription basis since 2011. If we in the printing industry would have spent only 5% of these extra costs on developing plug-ins for Scribus, we would today have a wonderful tool for free, which we could also give to our customers. VivaDesigner is already a very old clone of InDesign that can even handle *.inx files. It is very cheap, especially for educational institutions. The Affinity products should be known everywhere by now. Unfortunately, there are no Linux versions of them.

3. InkScape, CorelDraw, Affinity Designer instead of Illustrator . InkScape has three major disadvantages:

a) only the RGB colour space is supported throughout. However, if you are good at colour management, this should not be a big problem.

b) it can only do one page. The latest version can already handle multipage documents in a rudimentary way.

c) it can't do automatic line breaks with separations at the moment. It would actually be no problem to integrate the separating mechanisms of LibreOffice into InkScape.

CorelDraw is an established programme and a leader in Germany for stamps and automotive lettering, for example.

4 Gimp, Krita, PhotoPaint, Affinity Photo instead of PhotoShop. With Gimp all standard cases like colour space transformations, colour cast corrections, contrasts, resolutions can be done well by now. Writing your own filters is no problem and there are many plug-ins. Corel Photopaint is a bit easier to use than Gimp, but it costs money and cannot be extended.

5 Myiro, Datacolor instead of X-Rite. Myiro is a subsidiary of KonicaMinolta. The fastest colourimeter for the graphic arts industry, Myiro-9 was formerly sold by KonicaMinolta as FD-9. The software of Myiro is based on the software of Basiccolor, which unfortunately went bankrupt. https://www.myiro.com/myiro-9. Datacolor offers a good and above all much cheaper alternative to the X-Rite devices. https://spyderx.datacolor.com/shop-products/.

I apologise if that all was a little provocative. But I think I owe it to an international professional audience, if I may speak freely here as an employee of a public institution without pressure from a company, to describe honestly

the problems that really bother many colleagues and me, simply because we care about the printing industry.

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THE NEW U.S. GRAPHIC COMMUNICATION CURRICULUM: AN EXPANDED TAXONOMY

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Abstract
Survey and analysis of changing curricula of existing Graphic Communication programs within various degree granting educational institutions within North America. While some programs have closed, others have shifted curricular focus to adapt to newer disciplines entering the traditional graphic communication space, most specifically in User-Interface (UI) and User-Experience design. This phenomenon has changed the direction of the Accrediting Council for Collegiate Graphic Communications (ACCGC), an accreditation body in North America that reviews and provides accreditation to any participating programs in Graphic Communication. As such, the ACCGC has developed a Taxonomy of Disciplines that assist in determining criteria for accrediting newer and evolving Graphic Communication programs.
Keywords: *Curriculum, Graphic Communication, Learning Objectives, Taxonomy*

It looks like tough times are ahead for our industry as material shortages, labor shortages, and cost inflation continue to pressure margins and as the American economy slows appreciably, quite possibly into a recession.

But even the harshest business climates bring opportunity. Some industries hold up well, creating pockets

of growth, with market share and talent becoming available as the unprepared retreat into survival mode or fail. The advantage goes to companies that begin thinking now, before the downturn is in full swing, about how

best to capture those opportunities.

Printing United Alliance, 2023 State of the Industry Report (p. 13).

Introduction – Is Print a Turtle?

Is print still relevant? Is it an old turtle that slowly traverses through the forest unaware of the microscopic changes taking place in the world around him? Is the shell that protects him perhaps a hinderance to the landscape from which he walks upon? Is print represented as the shell of progression in the future of digitalized interfaces? As these are highly contested and philosophically demanding questions, perhaps questions that all graphic communication enterprises – and consequently, educational programs housed within higher-education institutions – have exhaustively grappled, the time has finally arrived to assess the future of education in the printing sphere and to consider the configuration of its shell.

As printing establishments close and educational programs shutter doors, the reality (and fear) begins to take hold. According to Printing United Alliance (2023), citing statistics from NAICS 323: Printing and Related Support Activities (U.S. Census Bureau, Census.gov), there was an 8.9% decrease in printing establishments in the United States from 2015-2022 (2020-23,392; 2015-25,688). In reference to the open quote of this paper, officers and leaders of major United States printing and graphic communication establishments cite direction and strategy as their most immediate and concentrated focus progressing into the remaining year of 2023 and the coming year of 2024. The Printing United Alliance Report (2023) posits, "Where should we take the company and how do we get there? Should we diversify? If so, in which directions, and what will we need to diversify profitably? Or should we stick to our core capabilities? Plenty of technologies, products, and services are creating buzz, but which are really opportunities given my company's resources, capabilities, and circumstances? How can we increase our odds of getting it right? (p. 24).

These questions segue most appropriately to higher-ed educational graphic communication programs as well. As bastions of innovation supporting the graphic communication industry, educational programs dedicated to this field have produced a budding workforce of highly talented employees and professionals that have helped to propel the industry and expand opportunities in technological innovation, advancements, supply chain management, training, and supplemental industries. However, as the digitization of content changed the landscape, and the reliance on printed matter waned, less-seasoned generations of talent entering educational institutions today have arrived with a diminished interest in the traditional printing technologies.

As such, programs within educational institutions have shifted, juggled, wrangled, and adapted to accommodate interests of digital natives through

the purveyance of customized intra-disciplinary foci and/or concentrations supplementing printing and graphic communication foundations. This is also a phenomenon experienced within the current printing and graphic communication industry, as evidenced by economic industry-based reports.

Complacency or Challenging the Status Quo?

Industrial, commercial printing, and publishing still remain a substantial industry from a global prospective. According to Reportlinker.com (2023), "The global commercial printing services market grew from $650.62 billion in 2022 to $670.92 billion in 2023 at a compound annual growth rate (CAGR) of 31%." Moreover, Reprotlinker.com projects the global market to grow to $740.03 billion by 2027. However, their definition of "commercial printing services market" is inclusive of "revenues earned by entities providing various printing services such as graphic designing, kitting, fulfillment, analytics, mailing, web-ordering portals, publishing, advertising, marketing, and retail to leverage business operations" (ReportLinker.com). As such, their prognostications for market growth expand well beyond the walls of traditional printing facilities and expand into other technologies and disciplines as well which are complimented by varying streams of design and digital web development and interaction contained within the auspices of marketing and advertising fields.

Educational Institutions

Graphic Communication programs within educational institutions today are faced with a rather challenging quandary comprised of interests (or lack thereof) exhibited by several forces. The first is the heavy pressure from university and college administration personnel who are concerned with enrollment, retention, and graduation rates affecting their bottom lines. The second pressure is from the graphic communication industry which needs highly trained on-floor production labor that requires wages competitive with other industries. Similarly, industry needs employing a workforce that is dedicated and driven through innovation, willing to initiate new opportunities in market expansion. The third force is the student of the future. Raised in a digital world, their interests reach beyond traditional analog printing and incorporate a multitude of integrated technologies and processes that resonate through design, interactive interface, programming, and web development. The fourth force, inevitably, is in the interested (and consequential influence) of the parents of the newer student generation. Versed in application as it pertains to economic forecasts, parents and families alike continuously question the future of the Graphic Communication industry as it fronts the

printing and publishing sectors, stimulating preponderance in the viability of their student's career choice and ability to generate a consistent and aspiring career path. Finally, the fifth force involves companies that purvey the very technology used in graphic communication programs, as well as the corresponding supply chain that supplies applicable consumables. As the uncertainties associated with chaotic economic markets, and the uptake of digital lifestyles dependent upon online and mobile technologies, companies and suppliers have experienced declines in sales growth in traditional printing technologies and supply chain consumables. Consequently, the support for educational programs have waned as well.

United States Graphic Communication Programs

In the 1980s and 1990s, there were over 50 four-year bachelor's degree granting programs in existence in the U.S. Once provided with healthy square-footage allotments in the forms of laboratories on the campus grounds complete with a comprehensive array of photographic darkrooms, image setting devices, printing and binding equipment, these programs attracted and produced a "ready-to-work" multi-talented workforce ready to enter any printing and/or packaging production environment. However, as mentioned before, the technological enhancements in the digital world evolved, interests in the pursuit of careers within the industry diminished and programs, not adequately prepared nor agile enough to supplement the offerings within the discipline for the purposed of attracting the new and future student, lost support from industry as well as from university administration, and, consequently found themselves closing doors and/or merging with other academic programs.

Currently, today there are 20 bachelor-degree granting programs in the United States and Canada (2023, Geisinger, Calkins, Wilson, p. 5). In the past year alone, three prominent programs have seized accepting applications for admissions into the Fall 2023 academic year. The reasons for the seizures are primarily due to low enrollment and unstable admission prognostications. Meanwhile, the remaining programs continuously monitor enrollment, retention, and graduation rates in compliance with university wide accreditation requirements as well as administrative forecasts pertaining to economic viability. As such, many programs have expanded their disciplines to include a vast array of fields that are commonly associated with the new graphic communication field.

What is Graphic Communication?

Over the years, the definition of graphic communication has mutated to best represent this "field." There have been two studies conducted that have furthered the conversation regarding how educational institutions (and subsequent organizations) with graphic communication programs are defined. According to Geisinger, Johnson, and Fulcher (2022), in citing the definition from The National Center for Education Statistics (NCES, 2022), write that Graphic Communication is "A program that generally prepares individuals to apply technical knowledge and skills in the manufacture and distribution or transmission of graphic communications products." This includes: "instruction in the prepress, press, and post-press phases of production operations and processes such as offset lithography, flexography, gravure, letterpress, screen printing, foil stamping, digital imaging, and other reproduction methods" (2). The NCES definition relies heavily on printing technology and the processes contained there within. However, when researching a few leading Graphic Communication educational programs across the United States, Geisinger, Johnson, and Fulcher (2023) revealed the following:

> *California Polytechnic State University, San Luis, Obispo, California, USA*
>
> "GrC is the study of how we convey meaning through visual design. This includes the creation, production, management, and distributions of advertising, marketing, websites, mobile apps, books, packaging, and other media in printing and digital form" (2022, p. 6)

> *Clemson University, Clemson, South Carolina, USA*
>
> "Graphic communication prepares students for professional careers in printing, publishing, packaging, graphics, digital media, content creation, and the greater communication industry" (2022, p. 5).

> *University of Houston, Houston, Texas, USA*
>
> "Students in UH go beyond a single profession. They are strategists who produce across print, packaging, emedia, eCommerce, simulation, app development, videography, animation, game development, and photography" (2022. p. 6).

Similarly, there are Graphic Communication academic associations that are affiliated with domestic and global programs that have pondered the classification of graphic communication as it applies to academia. Geisinger, Johnson, and Fulcher (2022) report that the Graphic Communication Edu-

cational Association (GCEA), "identifies in their GCEA Strategic Plan v4B (2018), the changing landscape and the need to stay relevant by moving on beyond the traditional print landscape and providing 'more value by helping our members develop new skills that help them position for the future workforce demand.'" (2022, p.2). Moreover, Anastasios Politis (2021), Chairman of the International Circle of Educational Institutes of Graphic Media Technology and Management (IC) and member of the International Association of Research Organizations for the Information, Media, and Graphic Arts Industries (IARIGAI) reports, "Evolution in industries and businesses, has led to the necessity for continuous transformation of the education and training in general. Global developments such as the internet, the development of digital media and the digitalization as a generic trend, are influencing tremendously the current structure of the curricula and study programs and lead to their necessary restructuring and transformations. This is the case with the Graphic Communication – Printing Science and Technology Higher Education" (p.1).

The Accreditation Council for Collegiate Graphic Communications (ACCGC) is a formal and official accrediting body that reviews, analyzes, and awards program accreditation certification at participating graphic communication programs both within the United States and internationally. According to the ACCGC website, "ACCGC defines the academic discipline of Graphic Communications as a branch of technology with focus on the creation, production, management, and commercial application of visual products in digital and physical form" (ACCGC.org, 2023). The ACCGC currently has awarded accreditation to nine (9) graphic communication programs (eight in the United States and one in China). Therefore, with the seizing and closing of various programs over the past few years, the Council has been forced to develop options pertaining to the longevity of the accrediting body. As such, there has been an appointment of a committee tasked in identifying opportunities for extending accreditation to existing programs as well as other potentially related disciplines. The committee that was formed consists of representatives from existing accredited programs as well as unaccredited programs. Upon its directives, the committee was tasked with the formation of a Delphi project targeted with the creation of a taxonomy that comprised of mapping out, organizing, and categorizing all relevant industry-related tasks, skills, and disciplines associated with the vast graphic communication field, as well as, authoring a comprehensive definition of Graphic Communication as it applies to the academe. After a series of discussions, and an exhaustive review that was vetted through industry representatives, academicians, students, and administrators, a final

taxonomical map and new definition was created, vetted, and published for purposed of defining the discipline.

According to ACCGC, the Graphic Communication discipline is "A branch of technology with focus on the history, creation, production, management, and commercial application of visual products in digital and physical form. Study may include combinations of business management, computer generated imagery, computer servers, content management, data, distribution logistics, graphic design, intellectual property law, networking, package design, photography, print production, visual product design, production management, project management, videography, and web development" (ACCGC, 2023).

The ACCGC Graphic Communications Taxonomy

Additionally, the ACCGC Delphi Group developed seven (7) relevant and applicable Student Program Learning Outcomes (SPLO). They are: 1.) **Design and User Experience** – Integrate design aesthetics, functionality, and relevancy into graphic communications products; 2.) **Production Skills** – Impact production efficiency and product quality across a variety of media by applying knowledge of graphic communications materials, technologies, and practices; 3.) **Teamwork and Project Management** – Contribute to graphic communications project teams for design, production, and management; 4.) **Legal and Ethical Considerations** – Recognize and practice legal and ethical responsibilities concerning the creation, use, and distribution of graphic communications assets or products; 5.) **Communication** – Communicate ideas through written, visual, and oral mediums to a wide range of audiences; 6.) **Research and Independent Learning** – Research and apply new information to solve graphic communications design, production, and management problems; 7.) **Business and Management** – Apply tools and principles in graphic communications business development and production management (ACCGC, 2023).

Resulting from the process, a larger comprehensive list of over 106 two-year degree granting programs associated in the Graphic Communication discipline in the U.S. has been assembled, created, and caste. Additionally, three (3) four-year degree granting Graphic Communication programs have filed applications for accreditation. The Graphic Communication Taxonomy has provided programs (existing and new) with guidance pertaining to future develop of curricula within their institutions – both interdisciplinary as well as multidisciplinary. Such a guide is imperative to gaining introspection for curriculum development, program modification, administrative require-

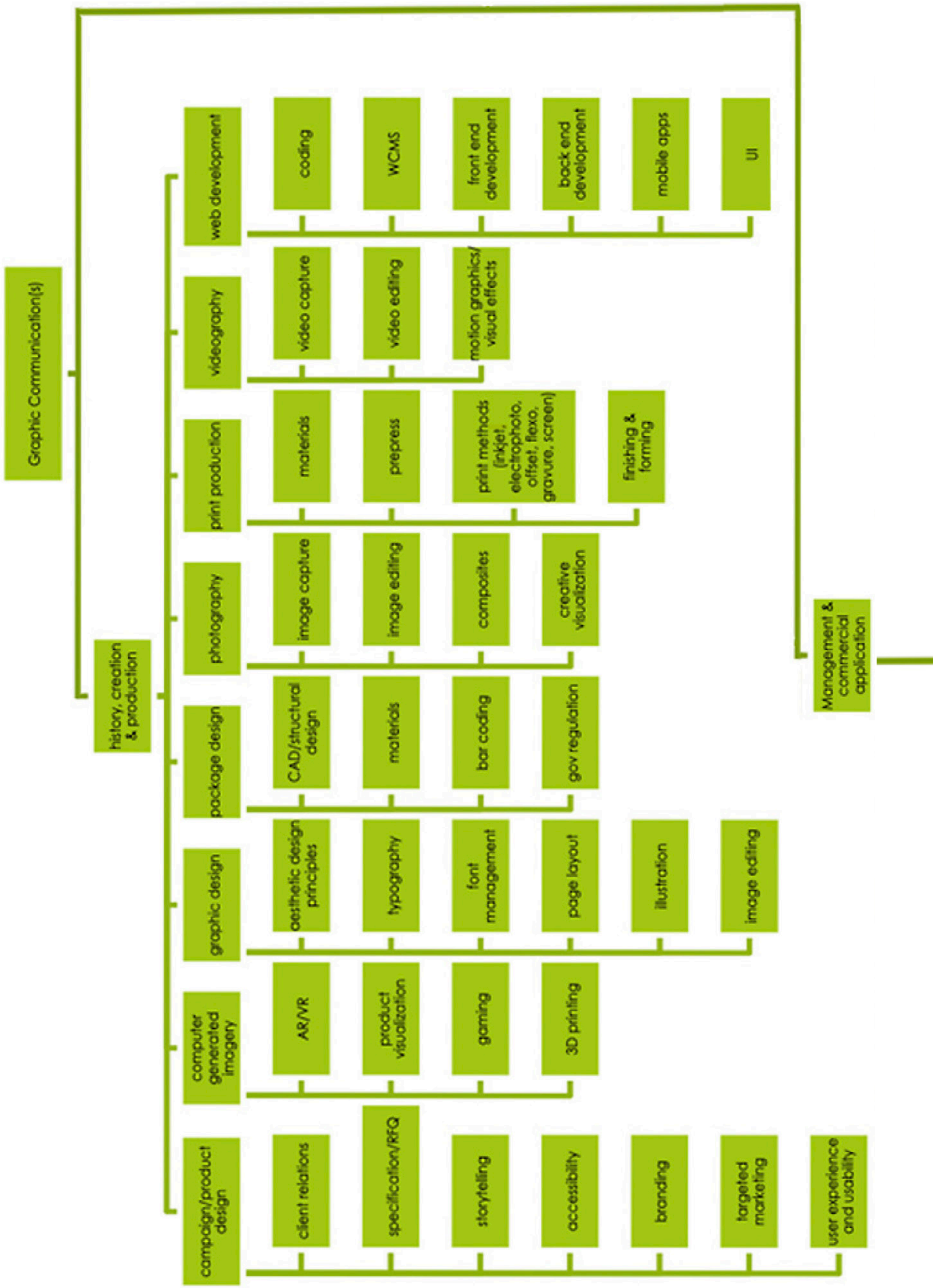
ments pertaining to enrollment forecasts, retention, and the enhancement of graduation rate efficiencies.

What do Future Students Want?

At the California Polytechnic State University, located in San Luis Obispo, California, students apply for the four-year Bachelor of Science degree in Graphic Communication (GrC) from all over the United States. The majority of students in the program come from California, with remaining cohort coming from the states of Washington, Oregon, Nevada, Arizona, and Texas. There are 390 students currently enrolled in the graphic communication program. As such, Cal Poly extends a core curriculum that focuses heavily on printing technologies, workflow, packaging, quality control, business, and management. Students then choose one of four concentrations: design reproduction technology (DRT); graphics for packaging (GPK); graphic communication management (GCM); and user-experience/user interaction design (UX/UI). As of the publication of this article, the distribution of concentrations is: 73 UX; 61 DRT; 16 GCM; 8 GPK (students choose their concentration in the beginning of their second year). As evidenced by the distribution of data, the majority of students in Cal Poly GrC choose user-experience/user-interaction design as the leading program. This can be attributed to the fact that many students come from Silicon Valley (San Jose, California) and are influenced to choose UX/UI from their families who are employed in the tech industry. As a result, the curriculum has changed over the past few years to accommodate needs and interests in video capture, augmented reality, virtual reality, artificial intelligence, user-experience design, user-interactive design, human-computer interaction, learning design, front-end web development, back-end web development and programming, as well as expansion into printed electronics and packaging interaction design, and integrated marketing communication.

Now, as Cal Poly's program does not necessarily represent the entire graphic communication educational community, is important to note that most of the existing 18 four-year bachelor degree granting programs have created and/or arranged their curricula to better serve the interests of their student constituency through the development of enhanced digital design-oriented disciplines.

The evolution of design has evolved to incorporate all aspects of communication. Beginning with the visual-ness of an object, whether it exist in an analog or digital world, it must be able to be transformed through all technologies. According to Yue (2022), "Visual communication design must be able to keep pace with the times and use more new technologies,


Graphic Communication(s)
history, creation & production
Management & commercial application
web development
coding
WCMS
front end development
back end development
mobile apps
UI
videography
video capture
video editing
motion graphics/ visual effects
print production
materials
prepress
print methods (inkjet, electrophoto, offset, flexo, gravure, screen)
finishing & forming
photography
image capture
image editing
composites
creative visualization
package design
CAD/structural design
materials
bar coding
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typography
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campaign/product design
client relations
specification/RFQ
storytelling
accessibility
branding
targeted marketing
user experience and usability

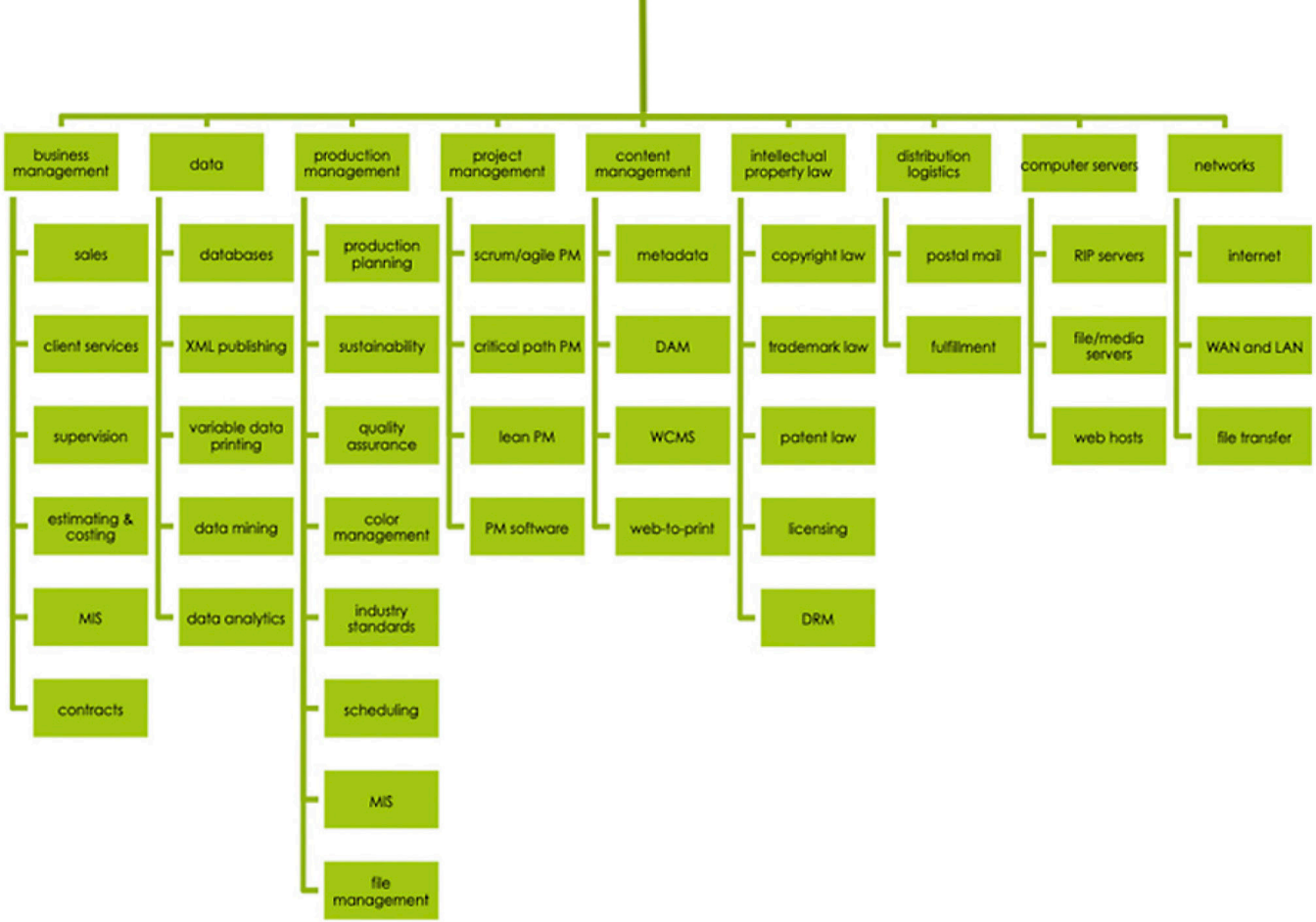

Figure 1. ACCGC Graphic Communications Taxonomy (2023)
https://accgc.org/wp-content/uploads/2023/02/ACCGC_Definition.Taxonomy22.pdf

and to integrate more new technologies with the innovative design of products, which has become one of the professional qualities of designers" (p.4). Therefore, interest in design and design technologies, the interactivity with the object – the "interactor's" perspective – becomes even more paramount to the success of the event and the comprehension of the medium. More importantly gaining an understanding of this from the form of a printed artifact enhances this theory as well. Neves (2017) writes, "Having served as a basis for digital development, printed matter has allowed itself to be only timidly contaminated by an explosion of concepts and possible involvement with a binary system. As processes of digital interaction increase, it is necessary to safeguard proximity of printed matter, resulting from graphic design projects, with people who actually use it, at the risk of letting become inadequate for lack of reinvention" (p.S4098).

When it comes to understanding the terms pertaining to interaction design, Schmidt and Huang (2022) report that User Experience (UX) is defined as an "Individual, perspective quality that manifests through involvement, interaction, and observable/measurable experience with technology or product. A consequence of internal factors related to the user, characteristics of the designed system, and the context of interaction" (p.144). Moreover, they define User-Centered/User-Interaction (UCD/UI) as "Offshoot of human-centered design used to describe iterative design practice that actively seeks user validation across all phases of design. Recognizes that users' needs, abilities, and desired should drive design at each stage of the process" (p. 144). Again, interactivity within the parameters of digital space remains the imperative. This relates to mobile design and integration of augmented reality (AR) as well. Youssef, Mousa, Baloola, and Fouda (2020) write, "In AR graphic user interface GUI is a combination of virtual and physical objects. These elements work together to achieve a fundamental goal, mapping user physical input onto Mobile application output. GUI focuses on three main factors: the physical design elements of the interface, the virtual visual display and the interaction metaphors between these. The AR graphical design should facilitate usability, and provides a high level of user satisfaction, perceived usefulness and consistency, so the design could easily be recognized and understand by user" (p. 97). In the field of human-computer interaction design, graphic communication – built upon the tools of printing fundamentals – provides the foundation for successful development, interpretation, and creative construction in both the two-dimensional printed space and the three-dimensional digital cyberspace.

Conclusion: An Inverted Turtle

Educational institutions engaged in field of Graphic Communication are continuously reiterating and defining their directions. Destined to satisfy the needs of the five forces and aggressively foster innovation in developing curriculum laced within a diatribe of an industry gone antiquated, the time has come to embrace the concepts of design as it matures within the progress of digitalization and all the interfaces that provide the window into content. Like a turtle having found itself on its back, struggling to overturn, graphic communication programs have found themselves in the same dilemma. Having carried the weight of printing and printing technology on their back for many decades, the shell protecting it has grown larger and stronger. And as the upright turtle slowly walks through the forest, the underside of its shell scrapes the rocks, sticks, dirt, and critters that pass beneath it. Like the turtle, Graphic Communication finds itself walking on dirt, sand, water – in the form of marketing, digital formats, and design – and fails to appropriately adapt to acknowledging the importance of it all as it walks over it. As students, however, begin to demand further development of programs that address newer digital experience design initiatives, the turtle (and the program) become inverted. Whilst attempting to reposition itself, inverted as it is, the uncomfortableness, awkwardness, and shear fear of never regaining an upright position becomes scary and challenging.

Although this lesson is not about the physiological, zoological, anatomical structures of a turtle, the meaning inferred here is that an inverted turtle has difficulties regaining its uprightness. And, for theoretical purposes, were the turtle physiologically capable of detaching itself from the shell (it cannot), it could – in theory – invert itself inside of the shell and continue its journey with the bottom side up – making printing technology the foundation, and the newer expanded fields the projected growth areas seen as the top of the shell. In the 2023 report generated by Printing United Alliance (2023), Chief Executive Officers were surveyed and asked where they foresaw opportunities in securing profitability in their futures. Inevitably, 38% responded that they envisioned expanding into new markets through diversifying product offerings as services such as web development, enhanced design services and application, as well as web and mobile app development (Printing United Alliance, p.6). The one question that was not asked of the CEOs who participated in the study, was where they predicted their workforce will come from and how their workforce will be trained, especially in these new and expanding areas. The answer comes from educational institutions that house and nurture progressive and innovative graphic communication programs that go beyond print. As a turtle gallantly displays the

brilliance of its top outer shell, it is bottom part of the shell that remains structurally vibrant, protective, practical, and applicable. Perhaps now is the time to invert our shells and begin a new process of evolution, one that values and integrates the legacy of print and integrates the future of interaction design and its taxonomical brethren. In reference to the opening quotation, it was written, "the advantage goes to companies that begin thinking now, before the downturn is in full swing, about how best to capture those opportunities" (Printing United Alliance, 2003). Perhaps the advantage goes to the graphic communication educational programs who – like the slowly progressive turtle who has adapted to a position of invertedness – have already determined how best to capture those opportunities.

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WOMEN IN PRINT: A SPECIAL CASE STUDY

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Abstract
The author - who is a woman, a printer and senior manager holding several positions - was recently influenced that motivated her to examine the situation of women in the printing industry more deeply and scientifically. Initially, she focused on Patria Printing House, the company she managed as CEO. The research puts emphasis on examining the proportion of women working at the company in total, and also in management positions. There was a question as to whether this diversity influences the company's effectiveness, so the subject of investigation is whether the development of balance sheet profit is related to the activities of female managers. Over the past 10 years, the ratio of the printing company's balance sheet profit to sales revenue has consistently increased. From this, it is not possible to draw the conclusion that this was due to the positive effect of the proportion of women in management, but it can be concluded that efficiency has not deteriorated. The question of equal pay for the same position, without gender discrimination, is important. It was also established that gender discrimination does not apply in manager positions at the company. While for the company as whole, the average salary of women is below that of men. This may also be explained by the fact that men occupy different positions from women.
Key word: *gender equality, statistical analyses, women in leadership, women in print, impact of women on business performance*

Introduction

The printing industry has traditionally been a masculine industry, with certain jobs and sub-skills still being mainly held by men. Even at professional events in the printing industry in Hungary, there is a significant majority of men in the audience (around 80-90%). Recently, a speaker from outside the industry remarked that the printing industry is lucky to have such a high proportion of men, because sectors that have become more feminised are performing worse (such as education or health sector). The statement is obviously based on prejudice, but it did raise the question in the author's

mind whether there is a correlation between the performance of firms and sectors and the proportion of women employed. Or whether the proportion of female managers has an impact on firm performance. In recent years, there have been publications on the situation of women in the printing industry, but these studies (Alexiou, Roberto 2022) have approached the issue mainly from a sociological perspective, rather than an economic one. Another actual issue is whether women and men receive equal pay for equal work. Decades ago, the popular belief and social expectation was that men were the "breadwinners" and therefore deserved higher wages. These misconceptions persist to this day, deeply embedded in social thinking. While there is a growing demand for a change in this perception. Many movements have been launched to improve the sociological, social, cultural and, of course, economic perception of women. The author, as a woman, as a manager of one of the largest printing companies in Hungary and a future PhD student, decided to examine the situation of women in the company she manages.

Methodology

The company under investigation is a security printing company with a 130-year history and 400 employees. The study used statistical analysis to examine the evolution of the proportion of women both in the company as a whole and in management, broken down by management level, over the period of years 2013-2023. Regression analysis was used to assess whether a correlation could be detected in the proportion of women in the operating result over the same period. The focus of the study's investigation was to statistically demonstrate the extent to which the "same pay for the same work" approach applies. The study compared the average wages of women and men in management and at the firm level, and in production where both women and men work in the same job. Statistical analysis was used to identify male-dominated jobs.

The main aim of the study is to analyse data from a specific company to highlight the gaps and help the company's HR department to improve internally. Also, a mini-pilot analysis for the author to explore further research and analysis ideas for the author's doctoral thesis.

Results

In the last 10 years, the proportion of women in the whole company has gone from 60% to 70%. If we look specifically at the proportion of women in the production areas, it is also 61% at present. It can be stated that the company employs a higher proportion of women than men and that this proportion has increased over the last 10 years. It may be an interesting question

whether this trend is representative for the whole industry at national and European level. And if so, what might be the reasons behind it. As a sample, I asked three printing companies with 100–200 employees about the proportion of women: these are 47%, 66%, 41%.

For the company in the study, a separate analysis was made of how the proportion of women in management has changed. The proportion of women in management has increased from 64% to 68%, meaning that women were already significantly represented in management 10 years ago.

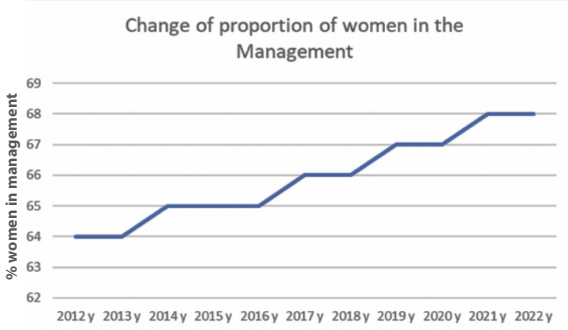

Fig. 1. Development of proportion of women holding management position between year 2012-2022

A closer look at each management level shows that the proportion of women has increased more significantly at the top management level, while it has decreased at the middle management level and increased at the team leader level. 1st level of management are the CEO and other directors. 2nd level: top managers but not holding director position. 3rd level: middle management. 4th level: team leaders.

Table 1. Proportion of women at management levels in 2023 Table

2023. February	Number of people	nr of women	women %
Management:	***63***	***43***	***68%***
1st level	6	3	50%
2nd level	5	1	20%
3rd level	15	9	60%
4th level	37	30	81%
Total company:	**389**	**272**	**70%**

Table 2. Proportion of women at management levels in 2013

2013. February	Number of people	nr of women	women %
Management:	**73**	**47**	**64%**
1st level	8	2	25%
2nd level	4	2	50%
3rd level	14	7	50%
4th level	47	36	77%
Total company:	**363**	**219**	**60%**

The study looked at the evolution of company performance, i.e. how the company's operating profit and turnover have changed based on public reporting. The results show that, with corrections, turnover has increased steadily, while operating profit has been increased too.

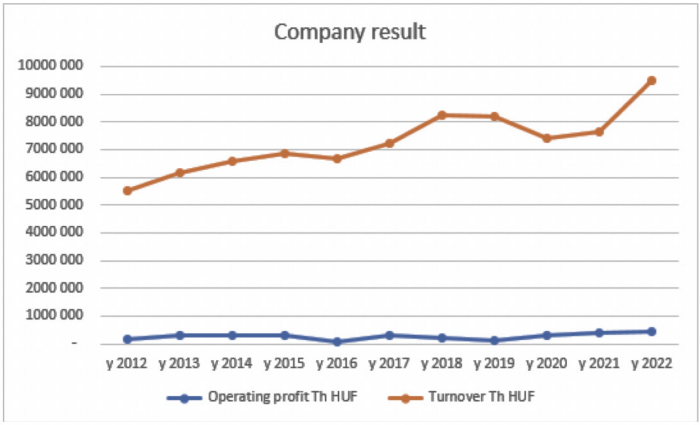

Fig. 2. Operating profit and turnover at the company between 2012-2022

Operating profit shows the real performance of a company, so, the trend line plotted by regression analysis of the change in the proportion of women and the operating profit shows visually that the company's performance increased as the proportion of women increased. Of course, with this much information it would be unfounded to say that this improvement in performance is due to women, but it can also be said that the increase in the proportion of women has not led to a deterioration in the company's performance (Hougard, Carter 2022) The positive trend line can be seen both in the proportion of women in the company as a whole, in the proportion of women in management and in the proportion of women in senior management.

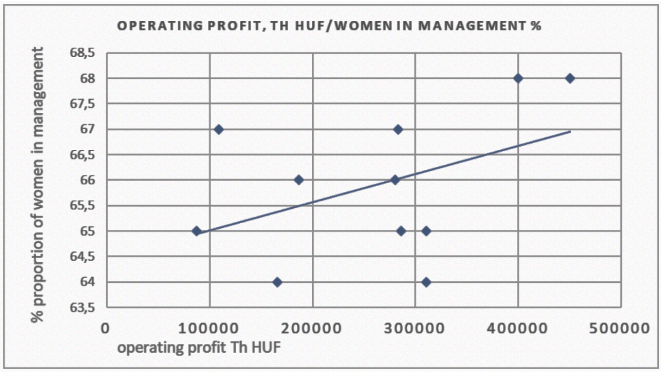

Fig. 3. Correlation between proportion of women and company's operating profit in the period between 2013-2023

Equal pay remains an interesting and sensitive issue (Ammerman, Groysberg 2021) In this study, only job and responsibility categories with the same content can be compared, so as not to be misleading. There were few cases of men and women holding the same job titles in the companies surveyed. One would think that men and women would have the same job in production, but a closer look at the total number of employees reveals that there are less than 10% of men and women with the same job, but that it is also spread over several areas. Therefore, in terms of pay, management and its different levels were examined first. The results showed that at director level (19%), senior management (8%) and middle management (14%), the average salary of women is higher than that of men, while at team leader level, men are paid more (10%).

Among production workers, the gender ratio was mixed among the 10 colleagues employed in mould making in similar jobs (10 women, 6 men). Looking at their average salaries, women are 1% more remunerated, which is not a significant difference, so in this area the "same work, same pay" approach is applied.

The study also analysed the average pay of women/men for the whole company. Surprisingly, the average salary of men is 32% higher than that of women. We have seen earlier that this difference is not due to the pay gap in management, but occurs at the employee level. As has been said, the jobs are different, it can be assumed that the difference is due to the content of the jobs, the jobs held by men may require more qualifications.

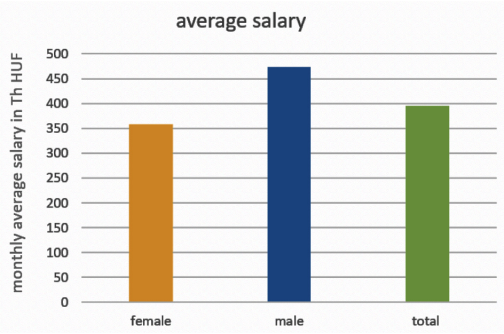

Fig. 4. Monthly average salary at female, male employees in HUF

In the context of the analytical problem raised, the study went on to identify those jobs that are typically male-dominated, defined as more than 90% of the employees in a given position being male. According to the analyses, male-dominated jobs are machine operators (either digital, sheet-fed offset, reel-fed or flexo) and cutters in the binding department.

Conclusion

In the company surveyed, the proportion of women in both management and the company as a whole has increased. It is worth investigating whether this is a typical trend at industry level with a European perspective. The reasons behind this change could also be the subject of research.

The study has shown that the increase in the proportion of women in the company studied has not worsened the company's performance.

On the issue of equal pay, women are not discriminated against in top and middle management, with group managers seeing higher pay than men.

The analysis of average company salaries shows that men earn significantly more in lower level jobs, but the analysis here needs to be complemented by a job analysis where salaries should be weighted by levels of expertise and responsibility.

It can be said that at the company the equal pay as a principle does not necessarily meets in lower-level jobs.

The study also identified male-dominated jobs such as machine operators and cutters in the bindery department.

A similar analysis of impact of women on performance and the topic of equal pay could be the subject of further research work with other domestic printers and with a European focus.

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PECULIARITIES AND METHODS OF STUDENTS' CREATIVE PROJECT ACTIVITIES

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"Creativity is allowing yourself to make mistakes. Art is knowing which ones to keep".

Scott Raymond Adams
Artist and cartoonist (USA)

Abstract
The aim: To analyse the factors that reveal students' creativity in the project activities.
Project activities promote students' responsibility, cooperation and creativity. Each project faces certain constraints, including scope, goals, and available resources. Working within a specific and defined project activity format, students look for ways and opportunities to reveal and express their ideas within a specified period, using particular materials, in order to achieve the goals set. The article presents insights on how to help students collaborate and engage in the creative process and methods how to encourage, motivate and unleash everyone's potential. The article analyses the peculiarities and methods of creative project activity, and the role of the teacher in involving and encouraging students to cooperate, work towards common goals, delegate tasks, and take responsibility.
Keywords: *project, peculiarities, methods, creativity.*

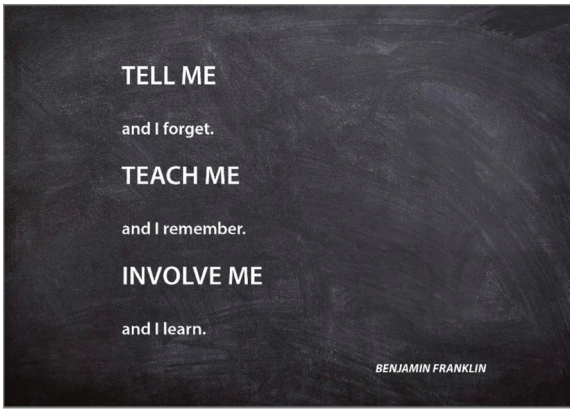
The concept of creativity and prerequisites for developing creativity

Creativity can be defined as the ability to generate new ideas, think 'out of the box' and independently, adapt oneself to new environments or conditions, address challenges and make appropriate decisions that open up new possibilities. Creativity is an essential individual's characteristic, an anchor for adapting to a rapidly changing modern world. From a psychological perspective, many people are creative, yet creativity manifests in the context of appropriate conditions for special education and development.

Art and creativity are inseparable. According to Fromm, one of the most famous humanists, psychologist and philosopher of the 20th century, it is necessary to provide the following five conditions for creativity to unfold:

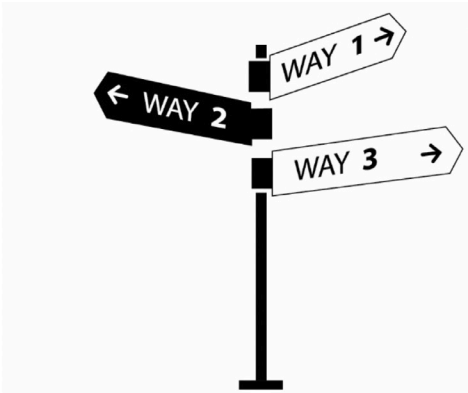
- The main condition. The *capacity for surprise*, the beginning of discovery.
- The second condition. The ability to *concentrate one oneself*, to perceive oneself *as the real one*, who can create, go beyond one's personality, merge with others, and feel unity with the entire world.
- The third condition. *Personal experience*. A sense of self that is the true centre of the world and the initiator of action.
- The fourth condition. The ability to accept conflict and tension without avoidance or evasion. Tension is a condition of human existence, essential for the development of spiritual strength and creative imagination.
- The fifth condition. *Courage and faith* allows one to trust one's experience and enables any new experience to emerge. To be brave means to allow the known to disappear, to dare to be different than others, and endure isolation. Without certainty and faith, creativity is impossible. As stated by E.Fromm, learning to be creative is learning to live.

Based on the above-mentioned theory, creation is considered a process, in which the individual's relationship to the environment or the existing reality is crucial. From a study perspective, the teacher and the student become partners, with the older and more experienced person helping the other to understand themselves and the environment. With the increasingly growing flow and a variety of information sources, it's the teacher's role to retrieve/extract information appropriate to student's abilities and to turn it into valuable knowledge.



The importance of project-based activities for creativity development

Project work is an important factor of creativity in the study process. Project work requires not only theoretical knowledge but also practical skills, taking the initiative and acting in a real work process, making decisions, planning and evaluating an intermediate or final result. In the course of the project activities, students cooperate with teachers and other people to analyse and address specific issues without being detached from social reality. The role of the teacher is to act as an initiator, to define the scope of the project, and moderate, motivate and supervise students throughout the entire project from the beginning to the implementation, from generating ideas to the final product. All the conditions for creativity mentioned by Fromm can be observed in the project activities, thus it is important to involve as many as possible students in the project. A 'project' is usually defined as 'a joint activity to solve a problem'. An elementary project scheme is "one problem + a group of people who solve that problem".



Through project-based activities, students learn to cooperate, work towards a goal and produce a final product, and the whole process is characterised by independent responsibility and self-awareness, respect for others and the contribution of different perspectives. Project-based cooperation is bidirectional, oriented "to students" and "from students". For project activities, it is important to make a team of different group members, as grouping students with different level of knowledge, skills and abilities help to foster positive interdependence and accountability. Diverse perspectives and experiences lead to higher competencies and provide experience for all students, both low and high achievers. When grouping students into mixed teams,

teachers have to consider the following factors such as working style and personality aspects. Grouping students with different character traits such as a shy student and brave one, or a risk-taking and cautious one, etc. works well. However, the teacher has to be sure, whether each student sees the value of the "opposite" contribution and how the student moves outside his or her comfort zone to try another character's role. Group work can be appealing for students when specific roles are shared. This makes each member of the team more involved and challenged. Which role to take may be assigned by the teacher or the students themselves. As the project progresses, the roles can be rotated and each student can try out a different role, allowing them to experience different roles and demonstrate their skills in various fields. The main roles are as follows:

Leader. In this role, the student facilitates the success of the team by assessing progress and keeping the team on track. The leader is responsible for the participation of each member. In addition, he has to ensure that each member of the team understands the concept and has the information required to implement the project.

Registrar. In this role, the student collects and shares information. He or she takes notes, summarises and describes the steps of the project: discussions and debates, and decisions are taken. The registrar is responsible for keeping copies of each member's work and preparing material for the final project submission.

Promoter. While a promoter, the student motivates his team members by attentively listening and inspiring students to generate new ideas, and building relationships and connections based on emotions and feelings.

Checker. In this role, the student has to ensure that each member of the team understands the given instructions and tasks, the specifics of the task and scope, when the task has to be completed and the goal of the team.

Timer. In this role, the student's responsibility is to ensure that the team meets the deadline and can complete the project promptly.

Runner. While a runner, the student finds a subject or an object that will help to answer the question or find appropriate resources the team needs to implement the project.

Correspondent. While a correspondent, the student's role is to pose a lot of questions to his/her team members in order to challenge prevailing ideas, generate new ideas and facilitate the team to move in new directions.

YOUR TEAM is a gift. Like a gift, you may not have asked for it. Even so, always show your appreciation for it.

Gifts are fun, so don't forget to play! But if you break it, do your best to fix it.

Sometimes the best gifts are those you didn`t want. It may take time to see your gift`s value.

LOOK. LISTEN. EXPERIMENT.
Share your ideas, skills and passion. Take risks, work and be a friend.

Wait and keep an open mind, give it a chance.

The surprise is half the fun. Enjoy what you discover *TOGETHER.*

The roles should be further clarified taking into consideration the specifics of each project (Pic. No. 1). In addition, it is possible to combine roles or assign more students per role, depending on the number of team members. The academic achievements of the students are not the key factor to determine the team's success. On the contrary, the team's ability to cooperate in order to achieve common goals has a significant impact on the project's outcome. The success of a project depends on how well the team members distribute the tasks and assignments and how communication progresses during the project.

Fig. 1 The great team of luminaire design project "Talking light", Kauno kolegija HEI, Faculty of Arts and Education.

Different working styles influence how members of the team interact with each other. Understanding a student's working style will help facilitate communication between team members, encourage conflict handling and support the successful completion of the project. Working style can be determined by an individual's choice to tackle issues. A student's working style undergoes certain changes over time. Moreover, it depends on the task or project and often reflects the working styles of team members. There are four major working styles: *driver's, expressive, sociable* and *analytical.* The driver wishes to commit and lead the team. Expressive students share ideas and information for free. Sociable team members do the tasks delegated to the team. Analytical members determine the scope of the project and evaluate the performance. When students are asked to take certain roles in the team, it is important take into consideration whether their roles correspond the specific working style. For example, to be effective in the "Leader's" role, the student has to maintain the driver's working style. To fulfil "the Checker's" role, the student has to adopt the analytic working style. Drivers help their teams to achieve goals. Expressive members motivate their team members. Sociable members help other students to manage their work in the course of the project. Analysts have to ensure the proper implementation of the project tasks. Each working style may have a negative impact on the team's performance. Drivers can give orders about what the team should do. Expressive members may be willing to continue discussions avoiding decisions. Sociable members may withhold their opinions in order to maintain a good atmosphere. Analysts may focus too much on details and minutiae, missing deadlines and team objectives.

To achieve maximum results, the team needs to properly maintain every working style from the beginning till the end of the project. In many cases, these roles can be taken by the same person (Fig. 2). It is important to be able to identify different working styles as knowledge help all team members to evaluate each other's contribution to the project implementation as well as to overcome obstacles when working styles contradict each other.

Major learning standards in the digital age are cooperation, critical thinking, creativity and communication. Project-based activities engage students in the real-world environment and provide them with more tools to compete in the 21st century global marketplace. These activities enable them to be more responsible, independent and competent.

Fig. 2 The results of luminaire design project "Talking light"

Conclusions

A project-based learning environment encourages students to pose questions, analyse, evaluate and draw conclusions, make further plans and generate ideas to take them to a higher level of thinking that requires feedback and assessment beyond grades and numbers.

Project-based team activities provide conditions for creativity, the joy and wonder of discovery, the ability to focus and experience initiative, accept conflict and tension, and foster courage and faith.

Project-based activity provides students with the conditions to experience an "authentic assessment", when not only knowledge of the content is assessed but also additional skills including creativity, cooperation, problem solving and innovations.

Summary

The article analyses creativity and conditions which help reveal individual's creativity, the teacher's role in project-based activities; and explores tools for developing a creative learning environment for students and methods how to motivate students develop their creative potential. The article presents the benefits of the project activity in terms of creativity education.

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DEFECT "GHOSTING" AS A RESULT OF THE INTERACTION OF PAPER AND PRINTING INK. FROM SCIENCE TO PRODUCTION

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Abstract

The result of the paper and the quality depends on various interconnected mechanical, physical and chemical processes what are affected by material properties, reset technologies, equipment and the condition of the production premises in the Print industry especially in the printing processes. Due to the complicate technological processes different defects can appear during the printing process which reduces the quality of production and causes financial loss. One of the main leading Printing company of Latvia "Livonia Print" initiated to explore and find solutions – to reduce or eliminate the risk of GH. GH has not been sufficiently studied so far. Consequently, there is not much specialized, professional literature available. Research sample of printing is taken from a real order, album, and it was printed under real production conditions. The result of the research is to reduce or completely eliminate risk of GH occurrence in the production of high-class printed works (albums, catalogues, etc).

Keywords: *Ghosting (GH), paper, ink, varnish, production, printing.*

Relevance and aim of the research

The GH occurs frequently, in both the sheet and web offset printing. It increases the costs of production and negatively influences the quality of the printed products, which brings to customer complaints and their refusal to pay. GH has been described differently in various literary sources by attributing the representation characteristic of another defect (Norīte at al, 2004; Vanaga at al, 2016).

According to the "*Dictionary of Printing Terms*", it is described as the occurrence or duplication of bands on printed sheets (Dictionary, 1995).

GH can be described as an increase in lightness or tonal change on one side of a print that corresponds to the motif printed on the reverse side. The GH defect is the appearance of darker areas on one side of the print sheet what cor-

responds to the shape which appears on the other side of the sheet immediately after the printing.

Gordon Pritchard in his article mentioned "Their appearance is usually unpredictable and, unfortunately, become evident only after the job has been printed and in the press delivery pile for a period of time" (Pritchard, 2011).

The GH is the printing defect (Kipphan, 2003). It increases the costs of production and negatively influences the quality of the printed products which brings to customers' complaints and their refusal to pay. The purpose of this study is to explore various information on the problems of GH: the reasons of its appearance and give the recommendations for reduction or elimination of GH risk.

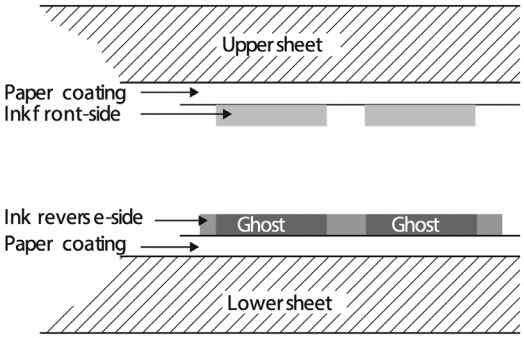

Fig.1. GH defect

For the study of problem, the printing company *LivoniaPrint* provided the material technical basis and implementation of the research results in the manufacturing process.

Failing to find information on scientific studies on the causes of GH occurrence and the possibilities of prevention in the conditions of production.

Craig Harmsen "Paper coating constituents and their influence on chemical ghosting" examines paper coating constituents, their degree of concentration, and that influence they play with regards to GH (Harmsen, 1982).

The German Association for Research in Graphic Technology has investigated the causes of GH on print samples obtained under laboratory conditions – *In the laboratory test, the varnishing of samples of all assessment levels took place with matt and glossy dispersion laquers. Although our tests*

show that the intensity of the ghosting is already minimised under these conditions for a certain ink paper combination, it cannot be ruled out that is still sufficient for a disturbing impairment of the visual appearance of prints (Sommer & Bertholdt, 2008).

Contact yellowing is often confused with ghosting, i. e. the matt/gloss effect, in which the first printing maps on the reverse print when perfecting (Test methods for offset inks and substrates, 2013).

Methodology

The author has summarized a lot of discussion with professionals of the companies, and has gathered other information about this GH as well as has done descriptive and analytical research and practical investigation under production conditions. SPSS database was used for statistical evaluation of the results. The three-factor analysis of variance was applied to determine the influence of factors and assess their relevant impact.

GH in sheet-fed printing originates through the interaction of paper, the printing ink, printing-press, print-related technological parameters and printed motif.

To establish the interaction of factors that cause the GH the following steps were carried out:

1. Potential experimental materials and printing technology were studied at *LivoniaPrint Ltd*. as well as information of manufacturer's datasheet on papers, inks and varnish.
2. Test printing schedule was determined, and the materials and technological equipment were prepared for test printing.
3. The experimental sheet offset printing was carried out in a controlled microclimate in the printing company. Printing parameters (printing speed, technology, printing sequences etc.) where measured.
4. The study of printed sheet, inks and paper samples was carried out in the State Institute of Wood Chemistry:
   a) Evaluation of GH intensity,
   b) Inks drying speed and dryness,
   c) Paper optical, physical and mechanical properties.
5. The results of the study were collected in a SPSS database and a three-factor analysis of variance was applied to determine the influence of different factors.

Results

For the study of the GH 7 sorts of 130 g/m^2 papers were selected; all of them are used in regular production at *Livonia Print*.

Table 1. Technical parameters of the properties of paper samples

Characteristic	Standard	Measurement	7B	6B	5B	4B	3B	2B	1B
Grammage	ISO 536:2012	g/m^2	130	130	130	130 (±4%)	130	130	130
Opacity	(D65/10) ISO 2471	%	97	97	96	96,5 (±2)	95,5	95	95
Thickness	ISO 534:2005	mm	129	125	143	108 (±8%)	–	–	110
Bulk	ISO 534:2005	cm^3/g^{-1}	0,99	0,96	1,1	0,83	0,85	0,77	0,90
Whiteness	CIE D65/10 ISO 11475	Index	118	119	120	118 (±3)	122	122	122
Brightness	ISO 2470-2 Light D65/10°	%	96	97	96	–	99	99	96
Smoothness Roughness	ISO 8791-4:2004 PPS 1.0	ml/min^{-1}	2,8	1,8	4,4	–	1,3	0,7	2
Smoothness	Bekk, TAPPI T479	s	–	–	–	200 (±50)	–	–	–
Surface gloss	TAPPI T480 75°, g.u.	%	< 20	25-30	–	23 (±5)	30	70	–
Relative humidity	TAPPI 502	%	–	–	–	50 (±5)	–	–	–

Each of the paper sorts was produced by a different manufacturer; the samples had differences in furnish composition and were covered with different coating. For the experimental printing 4 different printing inks were used in two printing-presses − *Heidelberg Speedmaster SM-102-8P* and *XL-106-10P*. Bacground: Moisturing solution – Combifix XL_805409; offset blanket – Perfect dot.

Table 2. Technical characteristics of printing inks

Parameter	1K	2K	3K	4K
Characteristic of ink	Sheet offset printing ink without mineral oils. Consists of organic and inorganic pigments and/or carbon black, resin and vegetable oil. Flammable to t^o C > 100°C. Viscosity, kinematic, mixtures	Sheet offset printing ink without mineral oils. Consists of organic and inorganic pigments and/or carbon black, resin and vegetable oil. Flammable to t^o C > 100°C	Consists of organic and inorganic pigments and/or carbon black, resin, additives and oil. Vapor pressure in kPa < 110 kPa 50°C. Boiling t > 35°C, Flammable to t° C > 100°C. Viscosity, kinematic >= 7 mm^2/s pie 40°C	Preparation of organic and inorganic pigments and/or carbon black, resins, vegetable oils and derivatives and additives. Density at 20° C1.04 g/cm^3 Organic solvents: <0.1% Water: <0.06% Flammable to t^o C > 100°C

The experimental printing resulted in 77 printed samples that provided the required measurements for the research.

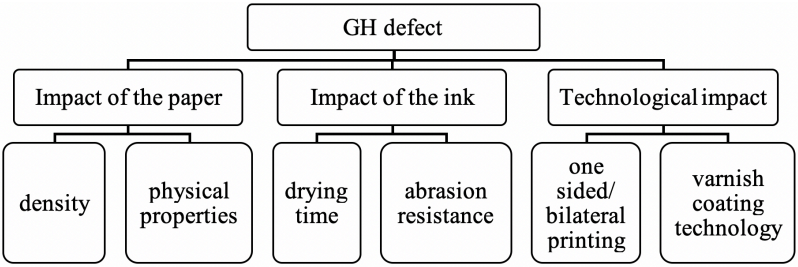

Fig.2. Research work structure

The study was conducted in three directions. The impact of paper, ink and technology on the occurrence of the GH defect was studied. As shown in Figure 2 measurements of density and physical properties were conducted for paper, drying time and wear resistance (abrasion resistance) for printing ink, technological effects – one sided or bilateral printing and with lacquering or without lacquering.

The assessment of materials and the defects of obtained printed samples

There were involved three independent experts of State Institute of Wood Chemistry to assess the quality of the printing under equal conditions, paying special attention to detecting GH. The experts rated the intensity of the GH of all the printed samples on either side of the top (front) and the bottom (back).

Graduation by their intensity: 0 – Invisible; 1 – Visible; 2 – Highly visible

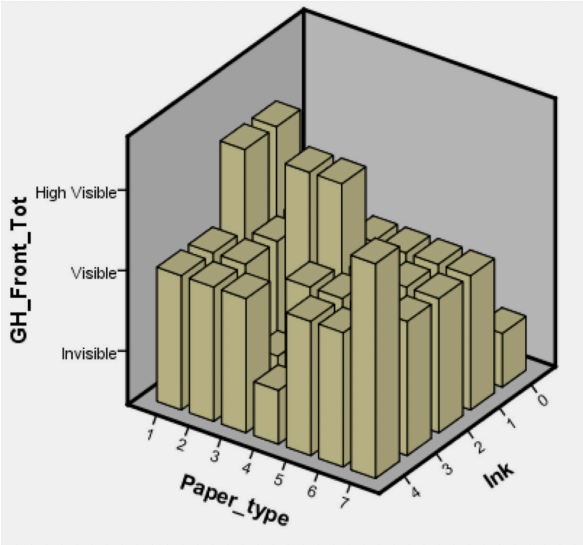

Fig. 3. Overview of results

The statistical analysis of the data shows that the greatest risk of GH is to apply varnish on still drying ink. After applying a layer of varnish, the drying of incompletely dried printing inks was stopped, but the varnish coating on the wet ink provides a two-component chemical interaction that enhances the curing of the printing inks and thus reduces the appearance of GH in printing.

Paper and inks laboratory test results and printing parameters were entered in a database (the program SPSS) in order to analyze the correlation of the factors and to find the causes of defect. As a result, the package of sug-

gestions will be developed for the company's possible technological solutions and correction of the physical-chemical processes in order to eliminate the causes of the defect.

There was carried out an acquisition of the results of technical measurements for the source materials, laboratorial study of the interaction of the physical and chemical properties of both paper, inks and varnish for the experimentally printed sheets, determination of the physical and chemical changes comparing to conditions of the references.

Separate ink/paper combinations differently present the GH. Its increase is observed at the increase of the thickness of the printing ink layers, as well as on print of both sides of sheets, when ink drying on sheet one side can affect the lower side of the paper. The origin of the GH in the sheet offset printing could be catalyzed by the different existing drying speeds of paper printing inks. The conclusions will become the basis for the output of the recommendations packet for the manufacturers of the printing and publishing industry.

Based on the summary of the results and the conclusions, it is possible to provide the suggestions and recommendations for the minimization of the GH and probably, its elimination in print production. GH cannot be exterminated completely at once, but it is possible to reduce the risks and find the best combinations of paper and ink. In relation to GH, certain ink/paper combinations have different properties. The defect increases with thicker layers of ink significantly and increases with double-sided printing markedly in two passes when it has been reprinted.

Conclusions & practical implications

1. In the experiment, GH was observed on every paper sample tested and the extent of the defect differs significantly. A higher risk of getting a "ghost" was on paper samples #1 and #4; lowest risk – on paper samples #2, #3 and #5.

2. During the experiment, it was observed that no natural based Magenta ink sample of any manufacturer was completely dry after 72 h.

3. The statistical analysis of the data shows that there are significant differences in the ink causing the GH. Highest risks were related to ink sample #1 and #2, medium risk – with the ink sample #4, while the lowest risk of producing GH occurred using ink sample #3.

4. The statistical analysis of the data revealed that the greatest risk of GH is to apply varnish on the ink "drying" because presumably the ink is not completely dry and thus after the application of the upper layer of the varnish, drying of the basic ink is stopped. On the other hand, varnish coat-

ing on the wet ink from the two-component chemical interaction enhances ink solidification, and thus reduces GH of printing.

5. It has been observed that varnish application and ink factors interact in 3 ways – without application of varnish, applying varnish on "dry ink" and applying varnish on wet ink. The smallest intensity of the GH was observed when applying the varnish on the "dry ink". Some printing samples would be suitable "applying by dry" technology. Minimal risk to obtain GH is varnish "application by wet".

Summary

1. GH happens throughout the speed of paint drying and following the fast printing of lower side can minimize GH at the critical material combinations.

2. Prevention of GH confirms once more that GH is matt/gloss effect in offset of supply of sheet paper.

3. In order to provide even the pace of printing-paint drying, it is necessary that on the sheet of paper exact reactive paint layer expels necessary oxygen amount inside of the stacking.

4. Without changing the printing technology directly for the printing of the processes described above, it won't be possible to avoid from the potential appearance of the GH defect.

5. A recommendation for this type of printed materials to choose technology that ensures in an instant drying and strengthening of printing ink.

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