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Competence training in the Printing Industry

Printed transparent Touchpads

Business Models and Strategy finding for the printing industry

Teaching Considerate Colour for people with colour-deficiency

Skills Gap in the creative industries in the EU

Colourimetric Values used by U.S. ink companies

UV- wide format inkjet package prototyping

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Dear Reader,

I am proud to present to you the 9th edition of the Circular. The on-line version of this journal can be found at https://www.internationalcircle.net/circular/issues/16_01 .

This edition has been made possible by the hard work of my predecessor Professor Wolfgang Faigle from the Hochschule der Medien (HdM), who is now in his well-earned retirement.

This Circular features seven articles that cover a wide range of topics. This is good, since it shows the very diverse interests of the members of the IC.

The first article talks about the need for standardization in the print industry using PSO and G7, but also for the need for constant learning of the employees working in the print industry.

The Science and Technology section is comprised of three articles. The first one talks about printed electronics using PEDOT:PSS in the ink to print circuits. The next article talks about the instruments that are used in US print and ink industry to measure colour and which colour differencing equation is used to express colour differences numerically. The last article in this section discusses the use of a wide-format UV inkjet printer for package prototyping and how the substrate used influences the number of Pantone colours that can be produced on this board with the UV inkjet CMYK inks.

The Education section features two very interesting articles. The first one identifies the skills gaps in the Creative Industries in the European Union and what can be done to close these skills gaps. The second article in this section makes the reader aware how people with colour-vision deficiencies see the world around them and how design can be adapted to accommodate them. I found this article particularly interesting.

In the Economics section is an article about the challenges the businesses in the print industry are facing in a rapidly changing environment. New strategic models are needed and Porter's strategy model can help finding these models.

From this short editorial you can see that the articles in this edition are very diverse and there should be at least one interesting article for every reader.

If you have an article yourself that you would like to get published please send them to me. I can be reached via email at mhabekos@ryerson.ca. You can write to me in German or English, but your articles need to be in English.

Best regards,

Martin Habekost

reviews

science & technology

education

economics

Competence Training in the Printing Industry: the key ingredient for optimal workflow management and standardisation

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Keywords: Total Quality Management, LEAN-manufacturing theory, 6 Sigma, Process Standard Offset (PSO), G7® Master Printing, Process Standard Printing

Successful printing companies must satisfy two basically contradictory requirements, namely bringing for cost reasons the cycle times of production to a minimum and maintaining the quality at a precisely defined and constant level. This goal can only be achieved through the rigorous use of modern management theories whose success must be made visible by certifications as an incentive to the employees and as a marketing tool to the customers in a highly competitive global market.
The process of implementing optimisation projects for the printing industry is lengthy. This is a period of time, however, is superposed on a constant phase of development, in which the employees' competence requirements are changing drastically and will continue to change even more in the future. This paper outlines a relevant critique on how companies understand the workflow process standardisation, employees' needed training goals on how to apply the standardised manufacturing processes, and, as a successful conclusion of the standardisation project, the target of FOGRA Process Standard Offset (PSO®) certification, or equivalent, of their manufacturing process as a proof of manufacturing quality excellence. To establish a proper education that also supports the industry management theories, it is hereby recommended joining the forces of the various different countries with an aim of bringing more young people into vocational education and training (VET) or higher education institution (HEI) study level of the Graphic Industry, and to train in anticipation already young specialists in modern print manufacturing theories and practices. This aim requires us collectively to improve the existing curricula by including industrial manufacturing theories, in order to avoid spending double resources and to support each other's efforts, so that we can keep VET, HEI and the printing industry sustainable. In this paper we will describe some examples from signed-off experiences whilst implementing at the printing industry level standardised workflows and quality control routines.

1. Introduction

During the lengthy process of implementing optimisation projects for the printing industry, which itself is in a constant stage of development, the employees' competence requirements have already changed drastically and will continue to change even more in the future. The emergence of various new technology "trends" often introduces a misleading image of where the printing industry is moving. In order to secure the sustainability of the printing industry, should be introduced the most important potentials for future production already in the early stage of industry developments. This preamble to the paper will introduce key-points, trends and provide relevant critique on how companies understand the workflow process standardisation, employees' training goals on how to apply the standardised manufacturing processes, and, as a successful conclusion of the standardisation project, FOGRA Process Standard Offset (PSO®) certification of their manufacturing process as a proof of manufacturing quality excellence.

Some of the European Union (EU) member states' printing industries, due to economic reasons, misleading propaganda or an insufficient competence level are unable to provide support for the standardisation projects for industrial manufacturing or to implement the Total Quality Management, 6 Sigma and ISO standards-based quality programmes on a higher level. Often, due to the lack of modern manufacturing theory and competency subjects at vocational education and training (VET) or higher education institution (HEI) level, the employee's trainings for the 5S, LEAN-manufacturing theories

[3] will start only when in industry, at which time the personnel characteristics are already established in the individual respective fields of printing, bindery etc.

To establish a proper education that also supports the industry management theories, it is recommended joining the forces of different countries with an aim of bringing more young people into the VET and HEI of the Graphic Industry, and to train already young specialists in modern manufacturing theories. If we can, all together, improve the existing curricula by including industrial manufacturing theories, then we can avoid spending double resources and support each other's efforts, so that we can keep VET, HEI and the printing industry sustainable. In this paper we will describe some examples from undersigned experiences, how to implement at the printing industry level standardised workflows and quality control routines.

Based on field experiences we have to look as well at the comparison of two printing industry quality methods:

- PSO used in EU and near global markets
- G7® Master Printing certification is used generally in the US and near global markets.

The standardisation methods of both leading organisations FOGRA and IDEAlliance include the best of their competencies. After implementing the standardisation routines (for example 5S, total quality management (TQM) etc.), the industry will have the potential to continue their process optimisation projects at the higher level, enabling the fine-tuning of the manufacturing routines toward PSO certification. Even by implementing developed manufacturing theories, it is not/will not be possible to replace the manual working competencies and skills that are required in order to work with high speed and with info technology (ITC) computer based machines in a company in accordance with job profiles and working place discipline, exactness, teamwork etc.

2. Problem definition

Common standardisation theories are mostly based on offset print technology in the field of media content or civil production. Due to the trend toward reduced length of print runs within traditional offset, production is quickly changing its focus to digital output devices or other printing technologies as well flexography, rotogravure etc. Some poorly focused assessments concerning the future trends of the printing industry, based adversely on technology "hype" are leading to the reduction of VET courses, resulting in the closing of well operating departments. Even worse is the frequent misleading of young people with the teaching of erroneous information stating that the printing industry leads to a heavy load and stress on the environment. To promote recognition of the changing trend of the printing industry, rather than a static leviathan, we should focus our standardisation routines as well as on sustainable printing technologies of packaging printing, printing on challenging substrates and giving generally high value for ITC and to the printed products, the electronics, diagnostics, pharmacy industries etc. Packaging and multi-technology printing will keep the production of print sustainable for the long term. As our studies have shown, all printing industry fields are in need of broad-minded specialists to be able to manage complex standardisation processes, and follow them up on a day-to-day basis in both manufacturing and operation.

To become a certified printing company is in reality not very difficult! It requires the ability to undertake a process analysis, understanding the process behaviour, envisioning the results of defined actions, teamwork, willingness and, above all, the vision to initiate it. To remain a certified service provider during the everyday production routine is, however, a much bigger challenge and requires lot of best practice implementations and continual optimisation. Due to the conventional nature of the printing process nature and the fluctuations occurring during the process, it is vital to implement appropriate modern manufacturing routines to provide the security of a stable, predictable and efficient production. In this paper we will analyse the possible drawbacks if the manufacturing process is not sufficiently stable due to the material environmental changes and the lack of competence to foresee the possible causes and results. Thus, the major issue is to keep production predictable and repeatable day-after-day. This requires a regime of follow-ups and continuous detailed process analyses. Often the misleading conclusion one hears once problems arise is that the issues in the production workflow are such that they lie beyond press operator control, for example in prepress output files, plates etc. In modern manufacturing process routines the bigger picture must include all process details, materials and a thorough dialogue between the different partners contributing to the according standardised, predictable process conditions and improved control during the time frame of the manufacturing, i.e. real time feedback involving all the operator control systems and the stakeholders in the process. To enable this, the first level of the monitored manufacturing process has to have at least a minimum contribution made by modern manufacturing theories and controls setup. Without full production flow management from in-put to out-put the problems occur more easily and the promised quality target certified will be a major problem to achieve.

3. The process

(I) pre-analysis, obstacles, challenges and needs

In this paper, we wish to start the discussion about the first level of the standardisation project in the printing industries, going through the implementation of the LEAN-manufacturing and 6 Sigma theories and finalise the project with the PSO or G7 certificate.

A modern printing industry needs to optimise and standardise their production workflows not only for quality reasons on long runs, but also due to the demands of reaching quality equilibrium early in shorter runs and increased competition on globalised markets. Today's common problems within the printing industry are caused by wrong or inconsistent day-to-day production routines. These may be human caused or arise from technical problems occurring during the production, and quite frequently an inappropriate steering response to the technology fluctuation made by the operator. Exemplified by experience out in the field, the following will describe some problems and obstacles that are common in the areas where we have been working.

Often, the start-up project at a printing house to standardise the production flow will not get finished. This is generally due to the following show-stopping issues:

1. Company has to make hard decisions to change company philosophy
2. Management and employees need to start thinking "out-of-the-box"
3. Necessary to design training programmes for employees and management
4. Need to recording the real starting point situation and values prior to the project launch
5. Make the analysis of the key values and technology processes
6. Design for the everyday routines and follow up programmes
7. Implement best and suitable manufacturing theories and practices
8. Adopt competencies inherent in the manufacturing theories and practices for the everyday production
9. …………………………………………..

Whilst the above points relate primarily to the challenge of having good management in place, the disappointment is even greater when we see that many companies whose management teams start the projects achieve some commendably good results, but when it comes to making the process the basis for everyday routine in the manufacturing, only a few can go on to reach the final goal. Therefore, already during the early studies at VET and HEI stage, students must be trained and taught to the highest level in progressive manufacturing theories. During the studies one has to understand the complex crosslink between manufacturing theories and printing standardisation according to ISO12647 standards [2]. After graduation, the young specialist can support the company management with the expertise in new ideas and become the future leader who implements subsequently the LEAN-manufacturing theory and champions the quality of the printing processes by PSO certification [5].

The general goal for standardised manufacturing is to speed up the manufacturing process whilst marinating quality reliability. The printing industry today is defined as the global business without regional limits, in which every company is facing the globally controlled quality demands and reduced cycle times. On the one hand, this makes the companies attractive for global customers, but, on the other hand, it makes them vulnerable due to the higher stress of manufacturing, where people start to make mistakes, lose focus and deliver unstable variable quality products. Due to the nature of the printing process it is never 100 % stable – this applies to all printing technologies! This challenges the technology engineering staff to develop responsibility and exclude as far as possible any variations, or fix them during the value chain standardisation project. The ultimate goal of industrial operation through this action remains to reduce costs and increase profitability!

The LEAN theory stands on 5 basic pillars:

1. Printer-customer relation
2. Identified process value chain*
3. From push to pull process systems
4. Improved process flow*
5. Continuous improvement – everyday routine*

Through this document we shall focus only on the pillars 2, 4 and 5 marked with an asterisk*, since these relate to both PSO and G7 process standardisation, and feature within the guiding help of the 6Sigma and Total Quality Management practice.

One of the major customer-defined priorities is quality. The classical definition of industrial quality is, "the quality that is accepted by the customer". No more, no less! The printing industry is dealing with quality complaints, product returns, price reductions etc. These are nowhere more strongly felt than in packaging printing. To manage all these limitations and ultimate stress, the best way to solve the problems is to standardise the total value chain, using progressive manufacturing theories, to train employees and evaluate their competence based on the resulting new job profiles and appropriate working conditions.

The target for process mapping and optimisation shall be clearly stated as Process Standard Printing. In modern industrial understanding we shall target our goal NOT only in the direction of offset printing processes, but as well toward other printing technologies. The basics can be taken from well-established offset methodology (example: Process Standard Offset [PSO] [6]). The accepted and qualified certification methodology has been developed only for offset printing, i.e. G7 and PSO, but, beyond that, the other conventional or digital printing methods can be aligned with ISO standards and technological requirements to meet proper visual results.

The modern printing industry value chain starts usually from the input files. This is where the current misleading information around the market impacts negatively, that the print operator does not have the control over the input files [1]. If we are dealing with the standardised value chain and industrial manufacturing, then the ISO15930 and ISO12647 standards requirements will lead to the identification and management of the quality level of input files. They are easy to check and analyse via pre-flight software or automated "hot folders". This is a valuable starting point, due to the fact that every pixel will be aligned according to standard requirements inside the input data. This is nothing more than the classical dialogue between print and prepress operators, but now via an adjustment at the software interface. Beyond that, general CS (Adobe® Illustrator®) settings will include the necessary ICC (International Colour Consortium) profiles during the file generation, which has to secure the first level quality assurance.

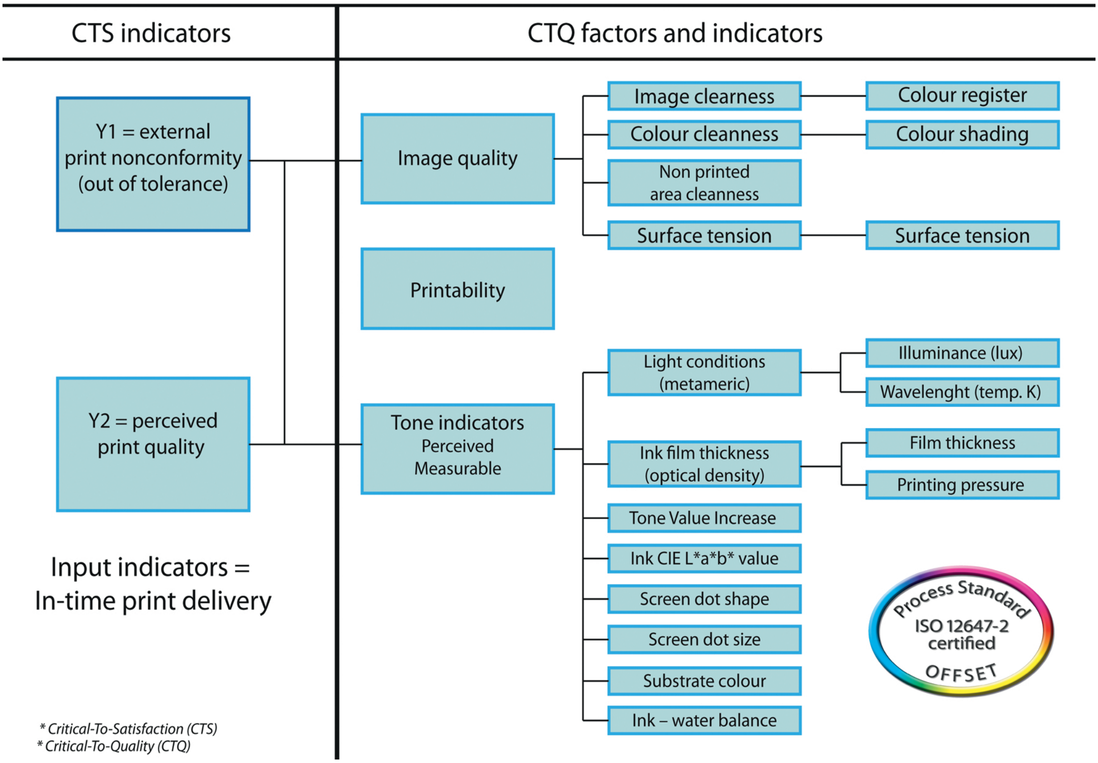

Figure 1: 6Sigma process table to secure the PSO certification (AS Metaprint) [5].

From the experiences in our files, printing companies often state on their web-sites, "For file preparation please use the common ICC profiles (example ISO_coated_v2.icc)," but in many cases at the printing machine the used inks do not meet the required CIE L*a*b* solid ink values! To solve this we are led to using the standard Value Chain Mapping requirements:

- View the entire Value Chain with all details included
- Design value chart with material and information interactions
- Define the non-value actions and sources
- Define the problems and design the improvement plan
- Discuss and keep dialogue open with all value chain members

The important part in guiding the printing industry is the integration of the 6Sigma. The 6Sigma alone is not in every case the ultimate speeding up tool, and does not always have the influence desired on overhead costs. However, a LEAN theory requires a high personnel cultural level of understanding and involves active participation of the company top management to avoid the failure of the efforts being invested. This has to be taken into account in the early stages of the project, so that the process is one of change and standardising activities that will be started right to the top level in the company to avoid unnecessary later misplaced criticism or destructive feedback. The first stage of the designed printing industry improvement shall therefore be started from the standardisation of the general value chain, and only secondly end up as a certified ISO-printing process.

The first stage of standardisation for the printing industry can be the same for both of the standardising methods (PSO or G7), being focused on the printing quality variables and defining them during the 6Sigma "Define - Measure - Analyse - Improve – Control" (DMAIC) design. By implementing into the everyday routines the 6Sigma DMAIC production quality will be predictable and controlled. Every event can be traced down through the process to the bottom level and analysed. The helpful tool on offer is to design the balance scorecard with cycle time and all measurable values. During the process, created waste or nonconformities must be recorded, analysed, translated into an action plan and tested again.

The final goal of the LEAN and 6Sigma activity remains to end up with standardising the printing process. Depending on the printing company location, there exist two general methods in the market:

1. PSO used in Europe and through FOGRA PSO partners on other continents;
2. IDEAlliance G7 used in US and through IDEAlliance G7 partners on other continents.

Both methods have the same goal – to standardise the printing process and secure the day-to-day predicted and controlled production quality.

From the marketing viewpoint, often representatives for each method try to show benefits of one method over the other method and this is understandable in respect to gaining sales. From the viewpoint of the physics and visual perception, however, both methods are equal in achieving the final result and quality.

During the LEAN and 6Sigma projects, one is naturally already solving value chain problems and setting up optimised workflows as well as optimising the printing technology and print environment simply following the ultimate goal of the project to reduce costs and increase profitability. This is all achieved with the help of the resulting agile production and predicted quality. The critics often say, that introducing a standardisation process makes the end product similar to all printing plants, and as a result we lose any unique perspective or desirable fingerprint in the production. In earlier days, as printing was more a craftsman-controlled production where every master added his personal touch into the end product, such a statement might have had validity, but today agile and industrial manufacturing has to be quick, flexible, profitable and formalised, such that there is no space for a print operator's personal touch, when having to be within the margins of best tolerance and stable quality. A niche printing house, however, need not be excluded, if a special run is required with a personalised "touch", as it simply needs to be run under predefined tolerances, which themselves can be unique. To achieve the results described above, it is necessary to improve the production value chain and keep in mind the final goal to certify the printing workflow according to ISO12647. This is to prove the company competence, to provide a security of the delivered quality and trust in the product being delivered to the print buyer.

(II) methodology: achieving the standardisation goal

The comparison throughout the certification development is made by considering the process steps, presuming that the printing press is in proper mechanical and stable condition. The input data are in digital form, and when in accordance with ISO15930 standard requirements we can state that the data set is under control. Before the document to be printed will be processed, the PDF/X quality will be checked and/or corrected to meet the ISO12647-2 standard printing requirements. To achieve this, we compare the process steps needed to reach the required colour quality of printing under the ISO12647-2 standard. The standardisation of the process means that the printing company will set up some limits that are derived from ISO12647-2 regulations. By choosing the substrate quality we align the requirements according to the description in the standard and in this way follow the impact of the substrate physical properties. If, say, one of the values in L*, a*, b* are lie outside the border limits of the ISO12647-2 standard, then the risk of nonconformity in production is inevitably present.

When providing a modern printing service, the paper/substrate is often part of the print provider's responsibility, and in these cases the substrate white point CIE L*a*b* values are respected and inbuilt as the first step in the exercise. In the case where a customer likes to have a different quality of substrate lying beyond border limits, the standard process per se is not fulfilled. In this reported comparison, therefore, we exclude the case of nonconforming substrate, and in this case in the comparison we label conforming substrates as Paper Types 1 and 2. According to our certification experience on the same Paper Types 1 and 2, the CIE L*a*b* target values can be used additionally for the standardisation of non-paper substrates with the similar white point values as Paper Types 1 and 2: exemplified in our chosen special case, the white point was L*-91,8; a*-0,3; b*-3.

The next, and second valuable step is the proper choice of CMYK printing inks. According to the existing ISO2846-1 standard, the printing ink tolerances are extremely wide and often do not correspond to the ISO 12647-2 standard colour set requirements. CMYK ink providers in the EU frequently supply specially mixed ink-sets especially for the PSO standardisation process, delivered with the special marking: "PSO applicable". From experience, the supplied ink sets are, nonetheless, still lying far away from the target values, depending in practice upon the nature of the substrate and allied printing behaviour. In cases like this, solid area ink CIE L*a*b* target values will already have a too large ΔE and altogether accumulate to nonconformity of the pre-estimated print production. During the LEAN documentation and application of the 6Sigma production process, value chain-mapping dialogue between print and ink provider is essential to set-up proper CMYK ink set quality conditions. This is a prerequisite requirement. After establishing the ink pre-set requirements, the 6Sigma concept of DMAIC will secure the predicted and stable ink quality for the daily business.

When the pre-conditions described above are fulfilled, only then is it reasonable to start to fine-tune the ISO12647-2 standard target values. To do this, we refer to measurements made on black backing.

From the ink and substrate point, both standardisation methods are starting from the same level of adjustments:

PSO – SOLID CIE L*a*b* value adjustments (ISO 12647-2 aim targets) [2].
G7 – SOLID CIE L*a*b* value adjustments (ISO 12647-2 aim targets)
Limit acceptable is ΔE <5.

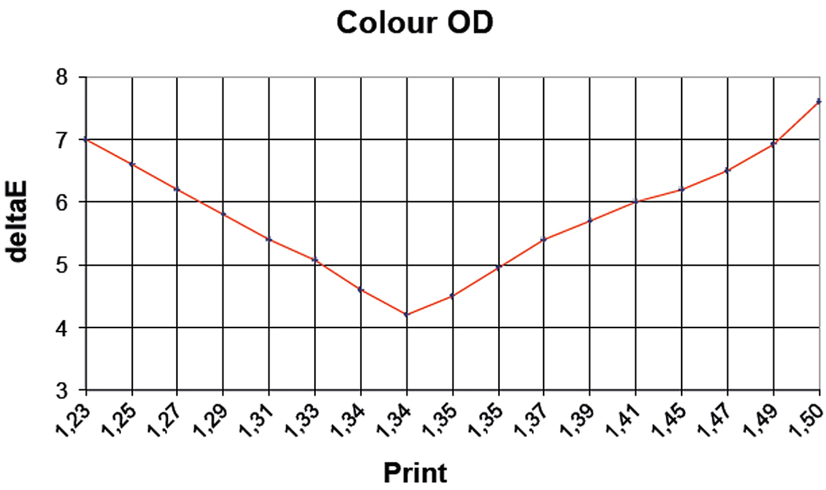

Figure 2: Solid area CIE L*a*b* value adjustments (ISO 12647-2 aim targets) for the print colour optical density space and acceptable ΔE

Based on the CIE L*a*b* the fine-tuned ΔE results can be fixed through the required solid ink density (SID) values, and the SID has a direct influence on the image visualisation quality, i.e. on the image components on the substrate. Due to the physical printing pressure, ink film thickness and optical influence arising from the screen dot size, this resulting influence has to be modified according to the ISO12647-2 standard tone value requirements.

Solid tone colour OK Print on Black Backing

Bottom left	Actual			Aim			ΔE*ab	
	L*	a*	b*	L*	a*	b*		
Black	16	0	-4	16	0	0	4	OK
Cyan	55	33	-51	54	36	-49	3	OK
Magenta	46	71	-1	46	72	-5	4	OK
Yellow	86	-3	88	87	-6	90	4	OK

Deviation tolerance: 5

Bottom right	Actual			Aim			ΔE*ab	
	L*	a*	b*	L*	a*	b*		
Black	16	0	-4	16	0	0	4	OK
Cyan	55	33	-51	54	36	-49	3	OK
Magenta	45	71	-2	46	72	-5	4	OK
Yellow	86	-3	87	87	-6	90	5	OK

Deviation tolerance: 5

Top center	Actual			Aim			ΔE*ab	
	L*	a*	b*	L*	a*	b*		
Black	16	0	-4	16	0	0	4	OK
Cyan	55	34	-51	54	36	-49	3	OK
Magenta	46	72	-3	46	72	-5	2	OK
Yellow	86	-3	87	87	-6	90	4	OK

Deviation tolerance: 5

Mean colour values of the secondaries on black backing (informative)

Bottom left	Actual			Aim			ΔE*ab	
	L*	a*	b*	L*	a*	b*		
Red	46	65	45	46	67	47	3	OK
Green	47	-63	24	49	63	26	3	OK
Blue	21	23	-43	24	21	-45	4	OK

Figure 3: Solid area CIE L*a*b* value adjustments (ISO 12647-2 secondary)

If the raster image processor (RIP) tone value increase (TVI) corrections are made correctly, according to the aim/target value table, and have left a sufficiently large working window for the print operator, then the colour gamut will map according to the FOGRA characterisation table (example: Fogra39). During this process, the technology engineers shall direct all their efforts, based on the local conditions, to achieve the ISO12647-2 standard aim values. Based on the ISO12647-2 standard, one must clearly differentiate the tolerances used for the fine-tune quality requirements in order to generate the contract proof versus those during the production run.

TVI correction as defined within ISO12647-2 is according to the table for Paper Type 1 and 2 (CMY 40 % max 13 %; K40 % max 16 %), with G7 – stated as secondary variable ISO12647-2, +/- 4 %.

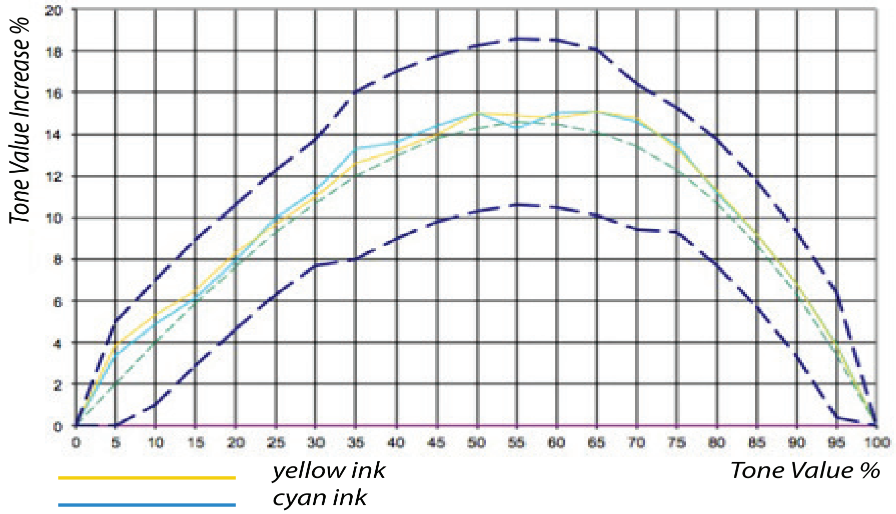

Figure 4: TVI – ISO12647-2 according to the table for Paper Type 1

The employees who are involved in the standardisation project must have the competence to understand how the human perception is working via the eye construction of vision. For example, why it is more sensitive to CIE b* value linear change than to the influence of CIE a* value change. This perception is controlled by the balanced grey during our certification processes with the proper RIP curve settings, will be within tolerances set for visual observer conditions under the K5000 condition, and measured via OD comparison between the target patches on the printed colour bar.

The next challenge at this point in developing toward the FOGRA characterisation table aim values and proper colour gamut is the calculation and iterative modification the RIP curves. Both standardisation methods are working via RIP settings to secure the production quality. In the PSO method, the RIP curve calculation is open for the technical staff to do, and it is possible to achieve the desired results with simple mathematics and an understanding of press behaviour. In the G7 method, on has to use a specific software tool to shift the curves of CMYK, which makes the process less transparent unless fully understood, which can lead to initially wider fluctuations for the inexperienced player. With training and experience, however, to set-up the standardised conditions during the project is not so difficult, but more difficult is to keep the production value chain working with maximum stability while adhering to the tolerances. The grey balance working environment is the quickest visual indicator to visualise the printing process fluctuation and to identify unexpected causes of faults arising during the press run.

In both methods PSO and G7 tools are valuable to assist in achieving the correct and stable grey values as closely as possible, and to monitor them over the ISO12647-2 standard CIE L*a*b* target value requirements. Thus, combining the ISO12647-2 standard aim values in respect to CIE L*a*b*, SID, TVI, the standardised printing process can be set up. To make the grey fine-tuning by the G7 method, the additional software tool must be used. In the PSO, all grey fine-tuning can be done using the standardisation team competence and knowhow. If the grey areas have a large per cent content inside the image area and the substrate CIE b* value is out of the ISO12647-2 standard conditions, then the additional help from the G7 grey balance software can reduce the time consumed to achieve the desired results. If more detailed fine-tuning must be implemented then the end result itself must support the visual perception comparison or the substrate printability properties are out of the standard conditions.

To keep the value chain under control during everyday production, it is not enough to use only PSO or G7 methods, but it requires the full combination of the LEAN, 6Sigma and Total Quality Management to be implemented to extend the security attained by implementing the PSO or G7 achievements. The general goal for future operators must be to become creators and to bring creativity into the industrial manufacturing routines in order to build up and inspire well-motivated teams keen to achieve the highest standardisation in quality and to achieve a production stability ethic.

4. Discussion

Tomorrow's print operator must have strong competencies in both printing industry technology and good manufacturing workflow. These competencies will become even more closely linked to the management of industrial production flows and of the production process. The purpose of developing and continuing to provide an updated higher level education curriculum together with LEAN management is to make the overall printing industry market attractive to young people and inspire them to exchange their knowledge with each other, and so allow it to retain and extend its rightly valuable role in cultural communication and transactions.

We are the generation who got our first sense of competence under the illusion of stable social conditions. In the future, however, we shall come to understand that rapid change becomes the norm in our mind. Our world has changed during the last years from an industrial society with prosperity and material things into a knowledge-based economic society concerned with self-realisation and experience. These changes mean VET instructors face a new task. Their knowledge and teaching methods must be continuously adapted to modern industrial theories and practices. This may require learning new manufacturing skills at university level. To complement the instructor development, expectations for the print operator are: a coherent attitude toward and understanding of new manufacturing theories, a willingness to change and be creative in an environment of improved workflows, and to act within a unified team, whilst retaining the ability of systemic thinking. Thus, they should enquire of themselves: how can I contribute? – how can I help define and influence strategy? – what should be my practical actions?

To enable the above to become reality, we have analysed and compared two certification processes, which not only act as tools to achieve an improved product and production quality ethos, but provide the operating environment for creative feedback in the process to target further optimisation. Both certifications will contribute to the final programme competencies that will support the growth of the industry knowledge. By using modern training methods, tools and learning environments, employees will have future-orientated competency courses, in which the practical work should reinforce the knowledge and skills from the training, and show how these can be used to keep real world tasks stable and within high quality requirements. Following training to achieve these goals, the manufacturing team must bring to the process the best competencies that they possess. Thus, we must lead young learners to work internally with self-discipline to develop those competencies during their life-long learning cycle. We must give to employees on their career path the knowhow that is needed, and prepare them to make the fundamental changes that the global economy will demand or require.

The new generation of manufacturing employees emerging from a strengthened advancement-training environment will support the overall efficiency of the industry by applying their competence in hi-fi production management theories, and by applying their understanding of the full workflow concept to the printing industry production. Strong printing technology competence makes companies more robust and encourages the industry to make hard decisions on fundamental changes of everyday routines, habits, traditions etc. Today's working specialists, who are graduating from VET or HEI studies, should be equipped with the additional competence to motivate and coach their team members to make changes. Agility and change will be part of our everyday life in the future. People in modern organisational structures need to be more involved in decision-making and in the process of transforming the organisation from the old "push" conditions to "pull".

The printing industry will continue to meet new ideas and challenging concepts, and company management can respond by utilising the competence of young printing operators in developing and adapting everyday production operations. Thus, the market will have printing operators with stronger competitive input – and this will feed back into vocational education such that it will be much stronger than it is today. With this approach, the printing industry will give to the labour market a strong positive sign that printing has much more to offer in future – it will make printing attractive as a career and maintain its attractiveness to the recipient of printed matter.

5. Conclusions

The paper outlines the value for the printing industry resulting from standardisation. It highlights also the need for employee competence quality and operator training to develop the skills to support the future for the cultural advancement in printed media, and argues strongly for unified commitment to achieve this vital development.

In addition to the needs for well-trained motivated operators and team agility in the workplace, the two standardisation norms, PSO and G7, are presented in parallel and their common principle described. It is shown that the grey balance is the basis for the overall process, and it is fine-tuned using the TVI (tone value increase) adjustment inside the RIP settings, which are in relation to the ink film thickness, substrate behaviour and printing press conditions. The TVI is adjusted and monitored on the full tone dot size reproduction area. This approach is needed due to human visual perception, i.e. the neutrality of grey has to modify in relation to the observer viewing conditions. The modern calibration and process standardisation methods using CIE L*a*b* colour aim/target values, tone value curve and grey balance adjustment methods both can guarantee ISO12647-2 conformance results.

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Fully Printed Transparent Capacitive Touchpads from PEDOT:PSS e.g. for Touchscreens - A Project of the HdM Stuttgart, Germany

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Keywords: Printed electronics, touch pad, printed circuitboads, silk screen printing

This paper was written by the author. The experimental work was done under his supervision and guidance by students of the HdM Stuttgart, which participated in a course with the aim to acquire practical experience. The here descripted results of the experiments have been submitted to the OE-A Competition for Multifunctional Demonstrators Based on Organic and Printed Electronics in the year 2013 and attained the second price in the category Best University Demonstrator.

Capacitive sensitive structures on PET or PEN films created either by screen printing or etching of transparent but conductive PEDOT:PSS are a cost-effective alternative to conventional structured indium tin oxide (ITO) films, which require sophisticated sputtering and patterning techniques for their production. Our new production method enhances the possibilities for film-based touchpads and touchscreens, leading to cost and weight reduction in new applications. The low costs and high performance of our production methods opens the door to a new generation of touchscreens by the possibility to implement high volume web coating and in-line patterning processes by screen printing and etching

1. Our Vision

What is the idea of our application? What advantage did we have in mind? The idea was to pick up the concept of conventional produced capacitive touchpads [1, 2, 3] and touchscreens and to turn it into completely printed applications.

Numerous digital equipment such as tablet PCs, smartphones, e-book readers, i-Pods, i-Pads, other audio and visual devices, automotive dashboards, and industrial controls uses capacitive sensors as input mechanisms. In this sensor technology the capacitance between rows and columns is locally modified, when a finger touches the panel. This shift in capacitance is used to identify the presence of a finger as well as its position. The point of contact is registered by a connected capacitive touch controller. For these capacitance sensors, usually printed circuit boards (PCBs) based on patterned transparent indium tin oxide (ITO) films are required. General advantages of capacitive sensors are their reliable operation and that they operate at low-power.
The aim of our project was to replace the conventional PCBs by screen printed or etched conductive PEDOT:PSS structures on PET or PEN films. As a result of our efforts, we have established a precise screen printing technology that fulfils the requirements to form a diversity of sensor circuits by using exclusively conductive PEDOT:PSS ink and inter-layer non-conductive ink.

Figure 1: Fully printed capacitive touchpad in front of the touchscreen of a smartphone.

Our project results not only in different designed touchpads but in a variety of demonstrators for capacitive sensors developed and successfully tested.

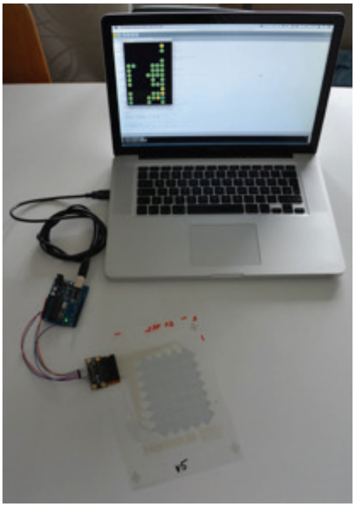


Figure 2: A capacitive touchpad with the evaluation electronics in interaction with a Laptop

2. The Realization of the Demonstrator

Functionality and electrode structures

The project description presented here focuses on 5x7 capacitive touchpads which are structured using a screen printing process. 5x7 corresponds to a structure with 5 vertical and 7 horizontal electrodes. At the intersection points these electrodes form capacitances whose values can be locally changes by touch e.g. due to touch of a finger. An external circuit detects this shift of capacitance. To enable the use of such panels as component of touchscreens, optical transparency has to be ensured in the touch-sensitive area of the touchpad, too. Therefore the sensitive electrode structures are realized on transparent foils with transparent PEDOT:PSS paste.

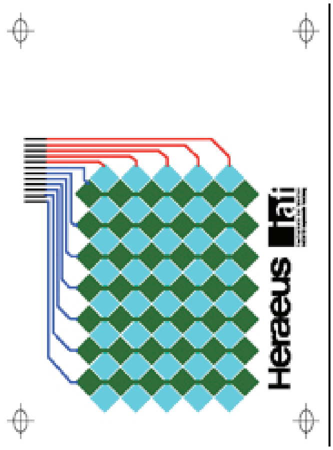


Figure 3: The layout for the screen printing of the capacitive touchpads

Even though the diamond structure features 5 vertical and 7 horizontal electrodes the capacitive touchpads has a total resolution of 9 rows and 13 columns because of the possibility to interpolate and thus determine positions between rows and columns.

The project touchpad was divided in two work packages:

- Work package 1: Determining appropriate dimensions of the electrode structures, their arrangement and the appropriate substrate thickness to ensure the functioning of a transparent capacitive touchpad. In addition an appropriate layout had to be designed to contact the electrodes.

- Work package 2: Programming and testing software to control the prototypes created in work package 1 via an USB connection with a laptop

The electrodes consist of a line of rectangular rhombuses, which are either horizontally or vertically connected and can be described as a diamond pattern. If a finger contacts the touchpad surface, the capacitance between the rhombuses of a row and the rhombuses of a column in the contacted area is altered. Through this change of capacitance the event of the contact itself as well as its location can be detected.

Additional circuitry printed on the foils connects the touchpad to a capacitive touch controller. This controller uses the signals at its input channels to detect the positions of touches and is communicating with a connected conventional microcontroller. The microcontroller performs first data processing and allows interfacing with a laptop. Thus a laptop is able to display the logged data created by the touchpad.

Structuring of electrodes

The PEDOT:PSS electrode structure was created by using two different methods.

- For the capacitive touchpads, which hereinafter are referred to as screen printed touchpads, the electrode structures were screen printed on PET foil with a special PEDOT:PSS formulation for screen printing in three different variants.

- For the capacitive touchpads, which hereinafter are referred to as etched touchpads, the used foil is on one side completely pre-coated with a PEDOT:PSS formulation by Heraeus

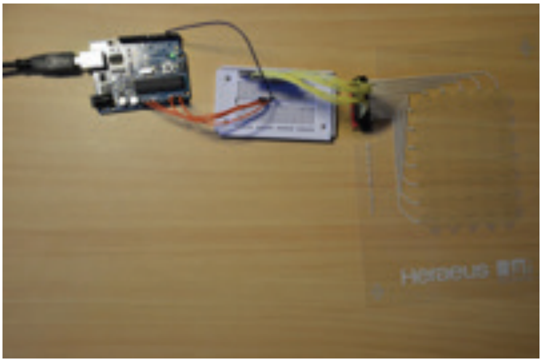


Figure 4: A highly transparent touchpad demonstrator of variant 5 on the basis of screen printed PEDOT:PSS in close-up view. As intended, the PEDOT:PSS rhombuses are hardly to see

Screen printed touchpads

- In the first successful tested variant of the exclusively screen printed touchpad, hereinafter referred to as variant 5, the horizontal electrodes are printed on the front side of a transparent foil and the vertical electrode structures on the back side of the same substrate. In this case the two electrode structures are electrically insulated from one another by the foil.

- For the second successful tested variant of the screen printed touchpad, hereinafter referred to as variant 6.1, the horizontal and the vertical electrode structures are printed on the same side of the transparent foil in two printing passes. The electrode structures are insulated from one another by an insulating clear printing varnish. This clear printing varnish is printed as a continuous film between the two printing passes for the electrode structures.

- In the third variant of the screen printed touchpad, hereinafter referred to as variant 6.2, the horizontal and the vertical electrode structures are printed with PEDOT:PSS in one printing pass on the same side of the transparent foil. However in this first printing pass the conductive connections between the rhombuses of only one of the electrode structures are included in the printed design. In a second printing pass these connection points are covered with an insulating clear printing varnish. Then the conductive connections between the rhombuses of the other electrode structure are printed with PEDOT:PSS on top of the insulating printing varnish in a third printing pass.

Etched touchpads

Capacitive touchpads that are processed using etching are based on a foil, which was fully pre-coated on a single side with a PEDOT formulation by Heraeus. To get the electrode structures, which are necessary for the functionality, a structured protective varnish is printed on top of the PEDOT:PSS coating in a screen printing step at the HdM. In the next process step the PEDOT:PSS coating can be etched in an etching bath delivered by Heraeus according to the instructions of Heraeus (under an exhaust hood due to the formation of chlorine). After this step the structures not covered by the protective varnish are electrically non-conductive and the touchpad has the same functionality as a screen printed touchpad.

Difference between entirely screen printed touchpads and etched touchpads

The partial etching of the PEDOT:PSS coating only leads to locally non-conductive structures but doesn't change their optical properties, thus delivering a completely invisible pattern. Therefore with this technique touchpads can be produced which can be favorably if highly homogeneous transparency is required.

Realization of conductor paths to contact the touchpads

Conductor paths, which are necessary to connect the touchpad to the capacitive touch controller are realized by screen printing conductive silver paste. The conductor paths run outside of the area of the actual touchpad. Therefore there is no need to have transparent conductor paths. In addition the conductivity of printed silver is orders of magnitude higher than of PEDOT:PSS and therefore leads to functional advantages, too.

Protection of the touchpads

To protect the electrode structures and the conductor paths from damages through direct touches an insulating clear printing varnish is printed on the entire front and back side of the touchpads.

Challenges to meet

For each of the different printed functional pastes the appropriate combination of parameters for the screen printing machine, the printing form (screen printing stencil) and the drying of the pastes had to be determined. For the printed PEDOT:PSS structures the screen parameters (geometry of the mesh and screen printing stencil) had to be optimized to meet the conflictive needs concerning the thickness of the PEDOT:PSS structures requiring high transparency and high conductivity at the same time.

3. What is the Target Group of our Application?

Manufacturers of conventional capacitive touchpads respectively touchscreens who intend to use the here presented production methods to reduce their costs of production and weights of their products. This opens new areas of applications for touchpads and touchscreens and may as well attract new manufacturers interested in innovative low cost capacitive touchpads, touchscreens and other sensors.

4. Advantages of Organic and Printed Electronics in our Application

The conducting structures of the touchpads as well as its connecting circuitry are completely printed, so their production will benefit from speed, simplicity and low costs of the printing process compared to conventional production. This will reduce complexity and costs of production.
The touch sensitive area can be extended to nearly every dimension and its layout can easily be adapted to new requirements of sensitivity, functionality, and size. Using our concept the application development of such sensors can be a matter of few hours, including prototyping through validation for production requirements thus reducing time-to-market by a significant amount.
Capacitive sensing finds use in all kinds of consumer, automotive, industrial, and medical applications. The popularity of this technology may further grow rapidly by reducing manufacturing cost, because

of its ability to eliminate mechanical components, and enhance product look-and-feel. Touch-screens constitute the major applications, but a growing use of this technology is also implementing capacitive keypads, wheelpads, and sliders. These applications may
also profit from our new production methods.But generally all circuit usage in areas where conducting and insolating multilayer structures are required may profit from our new production methods.

5. Electric Functionality of our Demonstrators

All our touchpad demonstrators consist of touch sensitive areas composed of a flexible foil on which a diamond structure of PEDT:PSS is printed in rows and columns. The rows and columns have to be separated by an isolating coating. This is either realized by the foil itself or an isolating varnish. When contact of e.g. a finger is made to the surface the local capacity is altered. To detect contacts and movements of the finger the local capacitances are measured using a constant DC charge current scheme and compared against threshold values. Because the area responds to near contact to its surface by any substances with a relative permittivity different from that of the air, contact can be made with any other pointing device causing a local change in capacity.

6. How is the Demonstrator Operated by the Capacitive Touch Sensor Controller?

All rows as well as all columns are connected to the input channels of a special capacitive touch sensor controller which is also which is connected to the microcontroller on a so called Arduino board.

The capacitive touch sensor controller is scanning its inputs channels that are the rows as well as the columns of the sensitive area. These scanning operations follow one another within milliseconds. During this operation the capacity of all crossings of the horizontal and the vertical structures are registered as well as checked if and where the capacity was changed.

7. What is the Function of the Arduino Board?

This row data are sent to the microcontroller on the Arduino board, which calculates the X coordinate and Y coordinate where the capacity was changed and transfers the coordinates to the via USB connected laptop to display them.

To receive the temporary position of the touching finger or other object continuously the activities described above have to be switched rapidly and repeated constantly. The source code including comments for this process is attached.

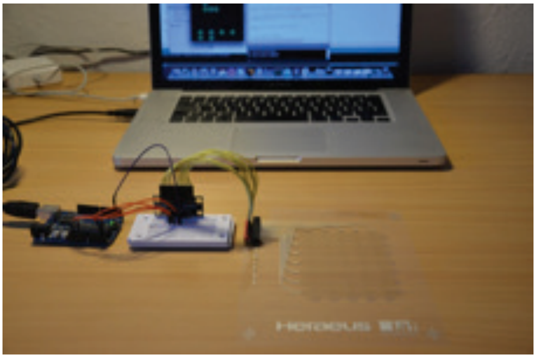


Figure 5: A capacitive touchpad demonstrator of variant 5 on the basis of screen printed PEDOT:PSS connected to a Capacitive Touch Sensor Controller MPR121, the Arduino and the laptop in close-up view.

8. How Are the Touched Coordinates Displayed?

The acquired coordinates are exported via USB port to a PC or laptop. By using the program language Processing the data are read from the laptop and displayed as single dots on its screen.

As depicted, two programs are used. First, the microcontroller reads the coordinates on the digital whiteboard and sends them to the PC or laptop, than the Processing language displays the read coordinates on its screen.

9. Printing of the Demonstrators

A dozen different demonstrator versions have been realized for tests.

Completely printed touchpads of three versions different in layer compositions as described in chapter 2 could be successful tested. Touchpads of version 5 are based on 125 Microns thick PEN foils (polyehylen-naphthalat, DuPont Teijin Films, Teonex). Touchpads of versions 6.1 and 6.2 are based on 175 Microns thick PET foils (DuPont Teijin Films, Melinex 504). As screen printable conductive polymers CLEVIOS™ PEDOT:PSS S V4 as well as CLEVIOS™ PEDOT:PSS S V4 HV from Heraeus Leverkusen have been disposed.

The etched and partly printed touchpads are based on a Clevios™ PEDOT:PSS formulation that is pre-coated on Kodak HCF-225 ESTAR™ film base. These pre-coated foils and the patterning process to structure them are developed by Kodak and Heraeus and delivered by Heraeus. The foils are highly transparent and more conductive then usual foils screen printed with PEDOT:PSS.

The patterning process using Heraeus component technologies creates invisible structures. To get the desired conductive pattern a masking polymer, Clevios™ SET S, is screen printed on the pre-coated foil. Then Clevios™ Etch is used to create the non-conductive areas. After the process is completed, the masking polymer that protected the conductive pattern is removed.

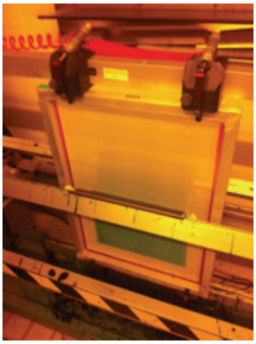
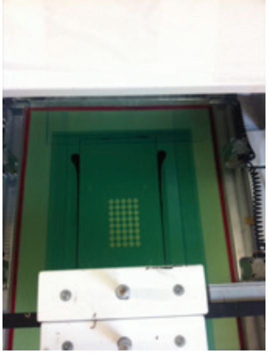


Figure 6: The picture above on left shows the silk screen frame while it is being covered with the emulsion for the stencil. The picture on right shows the silk screen exposed and developed stencil to print the structure with 7 horizontal PEDOT electrodes.

The CLEVIOS™ PEDOT:PSS for the touch sensitive area was printed with a 165-27 screen, the paste silver paste for the connectors was printed with a 77-48 screen and the isolating protective varnish was printed with a 120-34 screen. All screens are from the manufacturer Sefar and of type PET 1500. The PEDOT:PSS wet ink layer was about 5 microns thick, the resulting dry layer high of the PEDOT:PSS should be 0.1 microns depending on the number of printing passes.



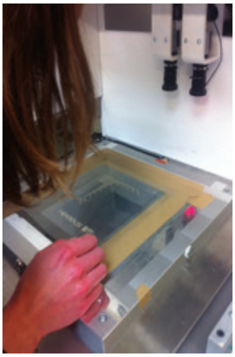


Figure 7: The pictures above show the silk screen form for the PEDOT:PSS rhombuses in the screen printing machine on the left, the silk screen form for the connectors consisting of silver paste on the right

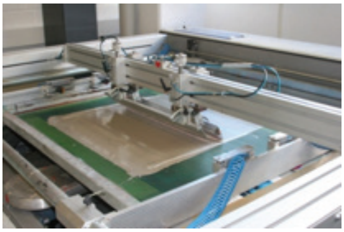


Figure 8: Screen printing of silver paste for the tracks of the connectors.

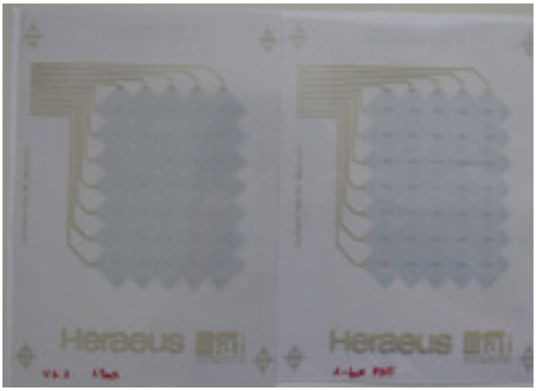


Figure 9: Finished transparent touchpad demonstrators of variants 6.1 and 6.2 whose sensitive diamond structure are realized by PEDOT:PSS. The connecting lines have been printed by silver paste. All conductive structures are covered and thus protected by an insulating ink.

Figure 10: Finished transparent touchpad demonstrators of variants 6.1 and 6.2 in front of a tablet screen. As intended, the PEDOT:PSS rhombuses are hardly to see.

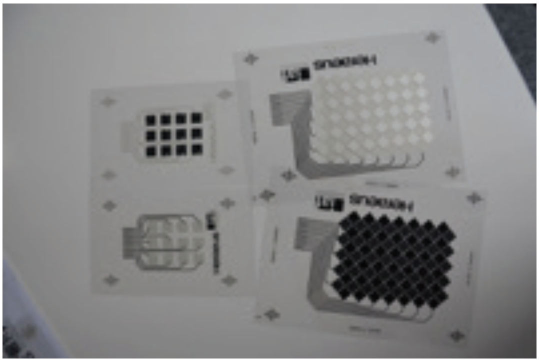


Figure 11: During our project we also realized not transparent capacitive sensors. Especially for keypads and touchwheels transparency is not always necessary. So we printed touch sensitive structures not only with PEDOT:PSS but also from silver paste as well as from carbon black paste.

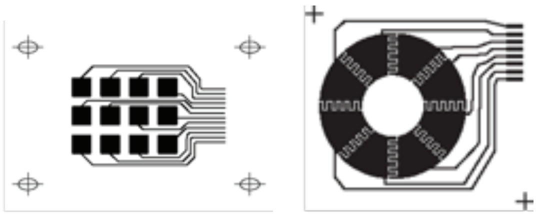


Figure 12: The layout sketch of capacitive keypads and capacitive touchwheels

10. Which Role Does Organic and Printed Electronics Fulfil in our Demonstrator?

Exclusively components of the toolbox have been use for the demonstrator:

- As substrates: PEN foils (polyehylennaphthalat, Teonex) and PET foils (Melinex 504). from DuPont Teijin Films.
- Screen printable conductive polymers CLEVIOS™ PEDOT:PSS S V4 and CLEVIOS™ PEDOT:PSS S V4 HV from Heraeus Leverkusen.
- Printable conductive material used for conductive connections of the touchpads (silver ink) as well as for not transparent capacitive keypads and touchwheels. (silver ink and carbon black ink) from DuPont Microcircuit Materials.

- Kodak HCF-225 ESTAR™ film base pre-coated with a Clevios™ PEDOT:PSS formulation.

The touch sensitive rhombuses consist of printed tracks from PEDOT:PSS ink on PET foil. Connecting conductors are printed by silver ink. Conducting materials are generally covered with insolating protective lacquer. If necessary for the correct functionality they are also separated by insolating inks.

11. Which Classical Electronic Components Are Used?

As classical hardware we used:

- A Proximity Capacitive Touch Sensor Controller MPR121[4, 5] and
- A Atmel AVR microcontroller out of the megaAVR series, e.g ATmega328

The here used Proximity Capacitive Touch Sensor Controller MPR121 has 12 capacitance sensing input channels dedicated for proximity detection. A complete capacitance measurement system is composed by sensing electrode pads connected to the MPR121 inputs. The MPR121 uses a constant DC charge current scheme for capacitance measurement. Each channel is charged and then discharged completely to ground periodically to measure the capacitance. All the channels are measured sequentially. The MPR121 is communicating with the host processor via an I2C bus and Interrupt output.

The Atmel AVR microcontroller controls the controller MPR121 and communicates with the via USB cable connected laptop. The microcontroller operates on the Physical open-source electronics prototyping platform Arduino. Arduino is an open-source based electronics prototyping platform including hardware and software. The microcontroller (e.g. ATmega328) on the Arduino board is programmed using the Arduino programming language, which is based on Wiring and runs under the Arduino specific Integrated Development Environment (IDE) which is based on Processing. Arduino projects can communicate with a laptop by a so called Serial Monitor, an integrated part of the IDE, or other software on a laptop like e.g. Processing, which was used in this project, too.

The microcontroller on the Arduino board also realizes first processing of the row data. The Laptop displays the detected coordinates and starts and stops the data sampling.

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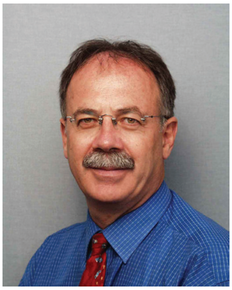

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Colourimetric Values utilized by U.S. Ink Companies

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Keywords: Colour differencing, DeltaE, Colourimetry, Standard Sperating Procedure, CIE

Abstract

Colourimetry is widely adopted in the printing industry, but the user-selected variables inherent in using the technologies are not widely standardized. In the present study, the current state of the adoption of particular colourimetric variables is examined in an U.S. ink companies. A quantitative, cross-sectional survey was distributed to ink companies inquiring about their selection of instrument geometry, colourimetric illuminant, standard observer and colour differencing method as part of their standard operating procedures. In addition, companies were asked about their choice for quality assurance software and preferred digital file format for colour communication.

1. Introduction

The widespread use of colourimetry has permeated the printing industry; colourimetric values are frequently utilized to manage and control both spot and process colour reproduction and are manifest in not only brand colour control initiatives, but also serve as the cornerstone of printing industry standards and specifications such as ISO/DIS 12647-2 (2012). When correctly implemented, the use of colourimetry enables the concise communication of colour values among stakeholders in the printing workflow, from concept to design to production. Colourimetry is applied in a wide-range of quality assurance applications from incoming materials inspection to process control applications. Clearly, one key goal in the adoption of colourimetry is to drive variance out of the printing workflow. Practitioners, however, must be wary of the myriad of variables inherent in the communication of colourimetric values, including illuminant, standard observer, and colour differencing method: unless properly managed, these variables could result in increasing variance in colour printing processes.

2. Need for the Study

Standards and specification committees for the printing industry reference selected colourimetric variables in their publications and mandates for relevant certifications. Many printers have moved from visual analysis and densitometry to colourimetric information for quality assurance applications in response directives from their customers. Print buyers and consumer brand owners increasingly demand consistent colour reproduction worldwide across a variety of substrates and media.

Ink companies in particular are widely regarded as being among the most influential users of colourimetry in printing workflows. The nature of the production of inks has practically mandated that manufacturers are early adopters of colourimetry to assure production consistency. Many ink companies pro-actively provide colourimetric data in reporting with ink shipments: some go as far as to print colourimetric information on the labels of their ink containers. As printers adopt colourimetric controls, they likely consult their respective ink company for assistance in establishing their own standard operating procedures (SOPs), which include the colourimetric variables examined in the present study.

While there are numerous examples of studies that compare various colour differencing methods (e.g.: Yu, 2014; Habekost, 2013; Chung & Chen, 2011) an extensive review of the literature revealed no published studies that examined which colourimetric variables are used by practitioners in this domain. In addition to an examination of which colourimetric variables are utilized, the present study also examines potential correlations that may contribute to a greater understanding here.

3. Research Questions

Utilizing a cross-sectional questionnaire instrument designed to examine the colourimetric variables utilized as standard operating procedures by ink companies in the United States is the primary focus of this study. Specifically, the following research questions frame the investigation:

RQ1. Which instrument geometry is utilized?
RQ2. Which illuminant is selected?
RQ3. Which standard observer is selected?
RQ4. Which colour differencing equation is utilized?
RQ5. Which, if any, software is utilized for quality assurance?
RQ6. Which, if any, digital file format is utilized for colourimetric communication?

In addition, the questionnaire inquires about the size of the responding company. The following hypotheses are tested regarding possible correlations among selected variables:

H1. The data indicate a correlation between size of company and quality assurance software utilized.

H2. The data suggest a correlation between software and colour differencing method.

H3. The data imply a correlation between software and file format utilized for the digital transfer of colourimetric variables.

Understanding the commonly used variables in this field and possible correlations can be relevant for a number of constituencies, including commercial printers and print buyers, industry manufacturers, educators, standards and specifications committees.

4. Literature Review

Literature germane to the present topic include published works that describe and define colourimetric variables, and those that compare and contrast those variables through psychophysical analysis.
A brief discussion of the variables examined in the present study is outlined below. Those interested in more detailed analyses here are encouraged to consult the cited sources for more information and specifics on the variables introduced.

4.1 Colourimetry, CIELAB, standard observer and standard illuminants

The process of quantifying the perception of colour is known as colourimetry. In industrial use, colourimetry is based on the work of the Commission internationale de l'éclairage, more commonly referred to as CIE, which is generally translated as the "International Commission on Illumination". Established in 1913, the CIE is recognized by the International Standards Organization (ISO) as an international standardization body (Schanda, 2007.)
CIELAB is an opponent colour system adopted by the CIE in 1976 as a colour model based upon a standard observer and standard illuminants (Berns, 2000). It is designed to be a device-independent, universal colour space representative of the range of colours perceptual to the 'average human' with normal colour vision. The CIE has defined two standard observers: a 1931 standard observer based on a testing individuals colour perception using a two degree angle of view, and a 1964 standard observer based upon testing using a ten degree angle of view (Schanda, 2007). Standard illuminants for colourimetry are representations of the spectral power distribution of light in numerical form; the CIE has defined several illuminants to represent particular light sources (Hunt & Pointer, 2011; Berns, 2000). These data are used to calculate the colourimetric values of a sample as it would appear under a light source that corresponds to the selected CIE illuminant.
When CIELAB values are derived from spectrophotometric readings, the standard observer, illuminant and spectral readings are factored to derive XYZ tristimulus values: the CIELAB values are based on those XYZ values (Berns, 2000). The instrument geometry from which the spectral data are derived is also a critically important factor in the use of colourimetry.

4.2 Instrument Geometry

Colour measurement instruments utilized by printing ink manufacturers measure the light reflectance of samples relative to a particular reference. Due to the surface characteristics of the samples measured and other factors, the instrument illumination condition and the incident angle of measurement are of critical importance. As detailed in Randall (1997), "Directional" geometry instruments measure directional light at 45 degrees incident to the light source, either illuminating at zero degrees and reading at 45 degrees (0°/45°) or illuminating at 45 degrees and measuring at zero degrees (45°/0°). "Spherical" instruments, otherwise known as d/8°, utilize diffuse lighting and measure at 8 degrees. These instruments generally enable users to read with the specular component of the light source included with, or excluded from, the colourimetric reading. Multi-angle instruments, sometimes called "gonio spectrophotometer" use directional lighting and measure at several angles, often simultaneously. Instruments that measure five angles are common multi-angle devices (Davis, 1996; Teunis, 1996).

4.3 Colour Differencing Equation, alternately known as colourimetric tolerancing method

The primary goal of a colourimetric differencing equation is to use objective, quantifiable measurements to replace more subjective visual analyses. Colour differencing equations reduce the colour difference between two samples to a single number. The CIE first published ΔE* (alternately known as ΔE*ab and ΔE76) in 1976 (Berns, 2000). This tolerancing method has been widely utilized in industry and by ISO procedures such as ISO12647-2 and ISO/DIS 15339 (Cheydleur, 2013; Warter, 2011).

In practical use, however, ΔE* proved to be limited as the CIELAB colour space is not visually uniform. In response to this condition, in 1986 The Colour Measurement Committee of the Society of Dyers and Colourists published an equation for determining colour difference, known as ΔEcmc (Hunt & Pointer 2011). The goal of the Committee was to develop a colour difference formula that better handled small colour differences. Later, the CIE created technical committees to examine the perceived limitations of ΔE* (Berns, 2000). Resultant equations of the CIE's work include ΔE94 (alternately known as ΔECIE1994) and ΔE00 (otherwise known as ΔECIE2000) (Hunt & Pointer, 2011; Luo, Chi & Rigg 2000; Wyszecki & Stiles 2000).

In addition to the technical literature, a number of psychophysical studies have been published that examine which colour differencing method best corresponds to human vision. Such research investigated samples with surface characteristics typical for the printing industry, and some have segregated trained and untrained observers in their analysis. These include several studies that have compared ΔE*ab to more current differencing methods in various contexts germane to the printing industry (e.g.: Yu, 2014; Habekost, 2013; Chung & Chen, 2011; Habekost, 2009). Generally, these studies conclude that in nearly all examined applications ΔE00 outperforms ΔE*, however in instances where ΔE00 is compared to other more current tolerancing methods (i.e.: ΔEcmc, ΔE94) results are generally less conclusive.

5. Research Design and Methodology

Using a self-reported mailed questionnaire instrument, managers at U.S. printing ink companies were identified using a list of such companies published by Ink World magazine (2014). Using methods suggested by Dillman, Smyth and Christian (2014), potential respondents were mailed an introductory letter, followed by a survey package consisting of a questionnaire instrument and postage-paid return envelope. In addition, a link to an Internet-based survey was provided as an alternative method of responding. Steps were taken to assure that all responses were anonymous. For example, the survey package also included a postage-paid return postcard, so that research subjects could indicate that they responded without revealing which response was theirs. Two weeks after the initial survey package was mailed a reminder was sent to non-respondents, and two weeks after the reminder mailing a second complete survey package was sent to those that did not respond. Of the 127 U.S. ink companies identified from the sampling frame, four were no longer in business, and one self-disqualified. In total, 49 companies responded out of the potential 122; a response rate of 40%.

6. Limitations

As a quantitative, cross-sectional survey, the present study is not designed to uncover the reasons that underlie why ink companies make their particular variable selections. In addition, as the sampling frame was limited to those ink companies in the InkWorld listings, large ink companies with multiple locations were represented by one of their centralized locations. Therefore, a small, single location and perhaps highly specialized ink company has the same weight in the present analysis as did a large organization with numerous locations. Further, this study is limited to those ink companies conducting business in the U.S. In addition, to streamline the questionnaire instrument, variables such as user-defined parametric values inherent in some colour differencing methods (e.g.: the lightness to chroma ratio expressed in the DE_{cmc} equation) are not examined.

7. Findings, Data Analysis and Results

The demographic information regarding the respondents is replicated in table 1. Large and smaller companies were generally equally represented: if responding companies are divided among those that employ 50 or less versus 51 or more there was a nearly even split.

Size of company		
Number of employees	**N**	**%**
< 10	8	16.3
11 - 25	11	22.4
26 - 50	5	10.2
51 - 100	9	18.4
101 - 500	9	18.4
> 500	5	10.2
Don’t know/Decline	2	4.1

Table 1: Companies in this study

Table 2 displays results pertaining to user standard operating procedures relevant to instruments and software: instrument geometry, quality assurance software and file format. In these instances, over 80% of users reported utilizing directional 0°/45° or 45°/0° measurement instruments. Four ink companies reported utilizing multi-angle instruments, while three reported using spherical instruments for their standard operating procedure. Turning to software, over 50% of the ink companies responding reported using X-RiteColour Master for their quality assurance needs. X-Rite iQC was the second most utilized software, with ten reported users and four reported using X-Rite ColourQuality as their standard. The only non-X-Rite software with more than one reported user was Datacolour Tools software, utilized by four of the respondents.

In terms of digital file format, the .mif format dominated with over 40% of users reported utilizing this particular type of file for transferring colourimetric information. This was followed by all versions of the .CxF file format with over 16% of users, and the standard file format for Microsoft Excel representing just over 8% of reported users. Of all of the variables examined here, file format resulted in the highest number of “Don’t know,” “Decline to answer,” and questionnaires with no answer selected represented 35% of the returned surveys.

Instrument and Software Variable		
Instrument Geometry	**N**	**%**
0º/45º or 45º/0º	40	81.6
Sphere d/8º	3	6.1
Multi-angle/Gonio	4	8.2
None/Decline	2	4.1
Software		
ColourMaster	25	51
iQC	10	20.4
ColourQuality	4	8.2
Tools	3	6.1
Smart	1	2
BASF	1	2
MeasureColour	1	2
Other/None/Decline	4	8.2
File format		
.mif	20	40.8
.Cxf (any version)	8	16.3
.xls/.xlsx	4	8.2
None/Don't know/Decline	17	34.7

Table 2: Information on instruments, software and file formats

Table 3 displays responses from colourimetric variables, namely illuminant, standard observer and colour differencing methods preferred as SOP. The "daylight" illuminants of D50 and D65 dominated as SOPs for responding ink companies, accounting for over 90% of users. Over one half of the respondents reported using D50, and over 40% selected D65. In terms of standard observer, the ten degree (1964) standard observer was utilized by over 53% of respondents, with nearly 39% choosing the two degree (1931) standard observer.

Colourimetric Values		
Illuminant	**N**	**%**
D50	25	51
D65	20	40.8
F2	1	2
None/Don't know/Decline	3	6.2
Observer		
10º 1964	26	53.1
2º 1931	19	38.8
Other/None/Decline	4	8.1
Colour differencing method		
ΔE_{cmc}	22	44.9
ΔE^*_{ab}	12	24.5
ΔE^*_{00}	8	16.3
ΔE^*_{94}	2	4.1
ΔE^*_{ch}	1	2.0
None/Don't know/Decline	4	8.1

Table 3: Colourimetric Variables

When examining colour differencing method, ΔEcmc is the most widely used among U.S. ink companies with nearly 45% of respondents indicating this is their choice for colourimetric tolerancing, while over 24% of ink companies reported using ΔE*, and ΔE00 accounted for just over 16%.

Turning to potential correlations among selected variables, the analysis examined correlations between the size of the company and the quality assurance software utilized, between the quality assurance software and colour differencing method, and between the quality assurance software and the file format. Due to the relatively low number responses, to test for correlations the data were regrouped to reduce the number of categorical variables, as illustrated in Table 4:

Categorical Variables for Correlational Analysis	
	N
Size of company	
≤ 50 employees	24
> 50 employees	23
Quality Assurance Software	
ColourMaster	25
Other than ColourMaster	20
Colour Differencing Method	
ΔEcmc	22
Other than ΔEcmc	23
File format	
.mif	20
Other than .mif	12

Table 4: Categorical Variables for correctional analysis

In an examination of a potential correlation between size of company and quality assurance software selection, a chi-square test for association was conducted. All expected cell frequencies were greater than five. There was a statistically significant association noted between size of company and quality assurance software selection, $\chi2(1) = 5.31$, $p = .021$. There was a moderately strong association between company size and software, $\varphi = 0.351$, $p < .05$. The data suggest that those companies with 50 employees or less are more likely to utilize X-RiteColour Master as their SOP for a quality assurance software.

In an examination of a potential correlation between quality assurance software selection and colour differencing method utilized, a chi-square test for association was again utilized. All expected cell frequencies were greater than five. There was no found statistically significant association between quality assurance software selection and colour differencing method, $\chi2(1) = 1.96$, $p < 0.16$. As the data indicate no association, the null hypothesis here is retained and it is concluded that software choice and colour differencing method are not significantly correlated. Finally, turning to an examination of a correlation between quality assurance software and file format, one cell had an expected cell count as less than five. Therefore the results of the Fisher's Exact Test are reported: $p < .005$ (2-sided). This finding suggests that those companies utilizing X-RiteColour Master are more likely to utilize the .mif file format as their preferred method for communicating colourimetric data digitally.

8. Analysis

In an examination of the types of instruments utilized by U.S. ink companies, it is no surprise that directional 0°/45° and 45°/0° instruments are the most widely adopted, as it is likely that densitometry is commonly still utilized in addition to colourimetric data, and 0°/45° or 45°/ 0° geometry is mandated by standards bodies for ANSI status density readings (Brehm, 1999.) Further, such instruments are generally less expensive, easier to use and available with smaller measurement apertures than their spherical and multi-angle counterparts.

The usage of daylight illuminants is also to be expected, although some may find it interesting that the D50 illuminant only represented one-half of the respondents: this particular illuminant condition is widely utilized in the U.S. printing industry as referenced in ISO 13655:2009. Likewise, respondents reported adoption of the two degree (1931) standard observer at 38% versus 53% adopting the ten degree observer. This finding may also be curious to some, as standards committees in the printing industry generally utilize the two degree choice.

The reported preferred use of ΔEcmc as a colour differencing equation by many ink companies is of particular note as ΔEcmc is not recognized by graphic arts standards and specifications committees to the extent of ΔE* and ΔE00 (Cheydleur 2013, Warter 2011. The second most widely used colour differencing method in this study is ΔE* and the more current ΔE00 represents the third most popular choice among responding ink companies. It is noteworthy that the data indicate if the number of ink companies using ΔE* and ΔE00 are combined, they still do not equal the nearly 45% of companies adopting ΔEcmc as a part of their standard colourimetric operating procedure.

In the examination of quality assurance software, clearly the X-Rite products enjoy the majority of the market share with U.S. ink companies, three of their software products are adopted by nearly 80% respondents. X-RiteColour Master is the most widely utilized, and is most likely the choice of smaller companies. The prevalence of the .mif digital file format may speak to the dominance of X-RiteColour Master as a software choice for quality assurance use as the format been a default selection of Colour Master users for many years.

9. Conclusions & Implications

In 1986, Fred Davis published a technology acceptance model for empirically testing new end-user information systems: theory and results, where he posited that perceived ease of use and perceived usefulness were direct antecedents to technology adoption. It is suggested here that the technology acceptance model (TAM) is an appropriate lens to view the implications of the present study. Clearly, the sheer diversity of colourimetric variables reported as SOPs by U.S. ink companies represents an interesting condition for the commercial printing industry: stakeholders who desire more homogeneity among the colourimetric variables utilized by industry are advised to build the case for the usefulness of selected methods to overcome the inconvenience of the incumbent changing their current SOP. For example, the present study indicates that a large percentage of responding ink companies prefer to utilize DEcmc. This particular tolerancing method is not recognized in ISO12647-2 (2013) which references ΔE* as a normative parameter with ΔE_{00} as the informative parameter (Cheydleur, 2013). Psychophysical colour differencing research that limits comparisons of ΔE* to ΔE00 could be leaving out wide swaths of the industry; users of DEcmc would be understandably unfazed by such studies. If DEcmc is meeting the needs of such companies, the moves of standards committees may hold little sway, especially if unsupported by convincing psychophysical evidence of the superiority of one colour differencing method over another. Restated in the view of Davis' TAM (1986), the perceived usefulness one colourimetric tolerancing method versus another may not be sufficiently significant to warrant a change.

This finding further suggests that the recent adoption of the file CxF3 file as an ISO standard format (ISO 17972-1: 2015) may not have an immediate impact on what U.S. ink companies continue to use: especially if this case is similar to the persistent use of DEcmc by many. It is reasonable to conclude that if ink companies and their constituents are utilizing file formats other than CxF3, and their selected formats perform well in their workflows, they will likely see little reason to switch unless a case for the superiority of CxF3 can be clearly and empirically supported. As with colour differencing methods, the recognition of standards bodies may be of little consequence to contented users of other formats.

10. Future research

Future researchers could adopt a more qualitative approach to print providers and buyers to obtain a richer understanding of the salient factors driving the choices that ink companies make in regard to colourimetric variables. Further, as this research is limited to U.S. ink companies, researchers may choose to examine ink companies outside of the U.S.

In addition, the present study potentially builds upon a rich tradition of technology adoption studies conducted since the seminal Rogers' Diffusion of Innovations was first published in the early 1960's (Rogers, 2003). As such, a point of reference for future potential researchers examining U.S. ink companies use of colourimetry and the respective variables is provided. Subsequent researchers may choose to re-examine ink companies in the future to better ascertain the stage of adoption of the variables examined here, as well as the relative influence of standards committees and software vendors on these variables.

Finally, researchers may wish to replicate this study with actual printers to better ascertain which variables such companies choose to select as part of their standard operating procedures: such studies could result in noteworthy comparisons to the present work.

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Using Wide Format UV Ink-jet Printing for Digital Package Prototyping

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Abstract:

Digital printing technology influences the short-run packaging and prototype market. Packaging work is among the most colour critical in the industry. Matching corporate and brand colours is essential, as is the ability to accurately reproduce spot colours. The main purposes of this experimental study are to (1) study colour reproduction and process capabilities of paperboard and corrugated board, (2) examine the quality of spot colour reproduction using a UV wide-format inkjet printer for digital package prototyping, and (3) establish printing workflows for digital package production. Sets of test samples were prepared to study colour reproduction and process capabilities of paperboards and corrugated boards using the EFI Vutek PV 200 UV ink-jet printer, to examine the spot colour matching capability, and to establish a digital printing workflow for digital package prototyping. Spot colours from the Pantone colour guide were used to design the spot colour test chart for this study. CIE L*a*b* values of Pantone colour swatches were used as target values. Adobe Illustrator CC 2014 was employed to generate the spot colour test chart in digital format. The designed test target was printed on different grades of paperboards and corrugated boards on an EFI Vutek PV 200 UV inkjet printer. The quality of spot colour matching was evaluated in terms of the ΔE2000 in CIE L*a*b* colour space.

1. Introduction

Digital printing influences the short-run packaging and prototype market, creating opportunities for print service providers to expand new services (Donovan, 2011; Balentine, 2013; Balentine, 2015). According to a recent report by Smithers Pira, the global market for digital printed packaging is forecast to be worth over $15.3 billion by 2018 (McEnaney, 2014).

The ability to print on a range of substrates, especially paperboard and corrugated material for the packaging market, makes the UV ink-jet digital printing technology attractive to package printers. Converters who traditionally printed only to paperboard are also leveraging digital platforms with UV-curable inks to explore new opportunities with other media, such as plastic, shrink films or heat-sensitive materials. Printing directly on a substrate gives the user a more accurate representation of the final package (Franklin, 2010; Donovan, 2010; Balentine, 2015).

Digital printing technology certainly provides a number of benefits that drive printers toward digital. Faster turnaround time, significantly lower costs, waste reduction, and greater flexibility are just a few benefits of digital printing technology. Designers can quickly produce variations of packaging designs or experiment with new concepts from design to final mock-up within hours (Franklin, 2010; Balentine, 2015).

The economy also plays a role in driving printers toward digital. Digital printing is critical in the context of the economic downturn, since fewer materials are used. More varieties and packaging sizes are fragmenting the market, leading to shorter runs that digital technology produces more economically. Print service providers can affordably add four-colour capabilities and print customized, variable material on demand. Packaging is also targeted directly to the consumers by placing their names on the packaging and making them feel that it was designed specifically for them (Donovan, 2010; McEnaney, 2014; Franklin, 2011; Balentine, 2015).

Packaging work is among the most colour critical in the industry. A brand's colours not only identify the product but also affect consumers' interactions with it. Prototypes need to be produced on the same media with the same colours and appearance as the final product (Peck, 2012; McEnaney, 2014; Balentine, 2013; Balentine, 2015). This research was conducted to investigate colour reproduction and process capabilities of tested paperboards and corrugated boards and examined the quality of spot colour reproduction using a UV wide-format inkjet printer for digital package prototyping. A digital printing workflow for digital packaging production was established.

2. Experimental Design

Sets of test samples were prepared to study colour reproduction and process capabilities of four types of paperboards and one B-flute corrugated board, to examine the spot colour matching capability, and to establish a printing workflow for UV inkjet digital package prototyping.

Equipment and Materials

An EFI Vutek PV 200 UV inkjet printer with UV-curable inks was employed in this study. This printer uses UV-A spectrum light to cure the inks. The EFI Fiery XF RIP was employed to control the printing processes. Four commercially available paperboards and one corrugated board were tested, which included 12-point, 18-point, and 30-point of solid bleached sulfate (SBS) paperboards, 18-point coated recycled board (CRB), and one B-flute corrugated board. The colourimetric values of the tested paperboards and corrugated board are illustrated in Figure 1. Tested paperboards and corrugated boards have natural shades of paper white, with the exception of 12-point SBS paperboard, which contains an optical brightener agent (OBA).

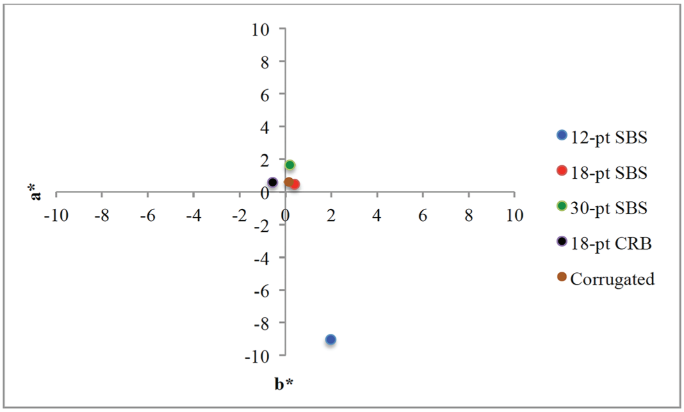


Figure 1: The colourimetric values (a* and b*) of tested paperboards and corrugated board

Test Target Design

Spot colours from the Pantone colour guide were used to design the spot colour test chart (Figure 2) for this study. L*a*b* values of Pantone colour swatches were used as target values. Adobe Illustrator CC 2014 was employed to generate the spot colour test chart in digital format. The spot colour test chart was saved as a PDF file.

Creating and Optimizing Profiles

The Fiery XF RIP provides a set of tools for improving the colour reproduction of output devices. For each tested paperboard and corrugated board, the tested charts were printed. The measurement device used in the study was an X-Rite i1iO Spectrophotometer. The following procedures were applied:

- Create a new base linearization file: a base linearization file forms the basis for a media profile, which contains details of the quantities of ink that are necessary to achieve the maximum density of colour for a specific combination of output device and media type.
- Create a media profile, which characterizes the tested paperboards and corrugated board.
- Load Pantone spot colour library so that spot colours can be automatically detected in Fiery XF RIP.

Print Modes

An EFI Vutek PV 200 UV inkjet printer was used in the study. The following print settings were kept consistent throughout the test runs:

- Shutter mode: double cure
- Lamp cure setting: medium
- Speed: standard
- Smoothing: heavy
- Printer output resolution: 360*600 dpi

Data Collection

Fifty test targets were printed and collected for each of the tested paperboards and corrugated board. Colour Reproduction Consistency and Process Capability Analysis.

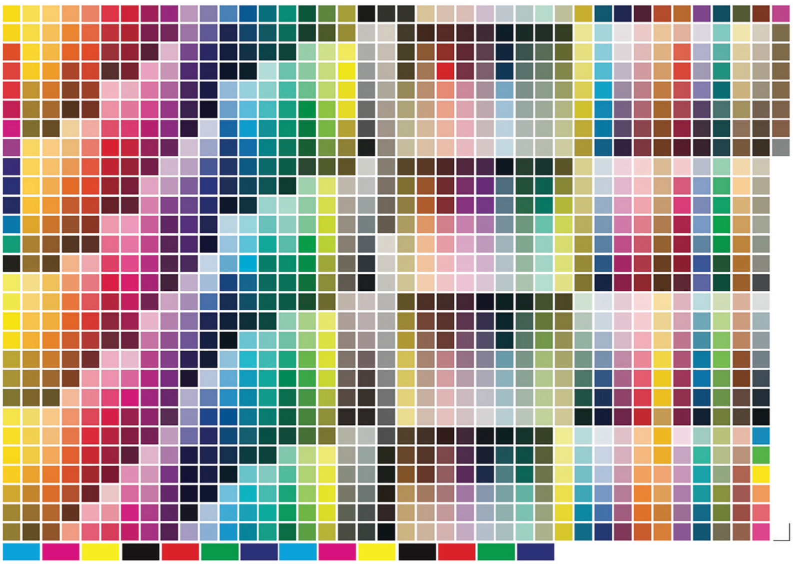


Figure 2: Spot Colour Test Chart

The colour reproduction consistency and capability of tested paperboards and corrugated board were discussed. This study uses the Cp index to measure process capability, which is defined as the ratio of the designated specification range to the individual paperboard and corrugated board process range, for optical density and colour gamut parameters. The Cp index is calculated as (upper specification limit - lower specification limit)/(6*Sigma). In other words, this ratio expresses the proportion of the range of the normal curve for each paper type that falls within those specification limits (Montgomery, 1997). For this study, a relative specification range was determined based on data for the selected paperboards and corrugated board and used to calculate the Cp indices, as described below.

Spot Colour Matching Capability Analysis
The spot colour test chart was measured by an X-Rite i1iO spectrophotometer at illuminant D50 and 2° observer. The quality of spot colour matching was evaluated in terms of the colour difference (ΔE2000) in L*a*b* colour space. The colour gamuts of the tested paperboards and corrugated board were compared using ColourThink Pro 3.0.3 software.

3. Colour-related Attributes

Tables 1 to 4 summarize descriptive statistics on the optical density values among the paperboards and corrugated board. The optical density values of the tested paperboards and corrugated board range from 1.54 to 1.80 for cyan (C), 1.23 to 1.30 for magenta (M), 0.76 to 0.83 for yellow (Y), and 1.56 to 1.87 for black (K). Among the tested paperboards and corrugated board, 18-point SBS paperboard has higher optical density values for colours cyan and black, while corrugated board has lower optical density values for colours cyan and yellow. 30-point SBS paperboard tends to have larger colour reproduction variability.

Factor	N	Mean	StDev	95% CI
SBS 12 point	50	1.62	0.05	(1.60, 1.64)
SBS 18 point	50	1.80	0.06	(1.78, 1.82)
SBS 30 point	50	1.60	0.05	(1.58, 1.62)
CRB 18 point	50	1.70	0.05	(1.68, 1.72)
Corrugated boards	50	1.55	0.04	(1.53, 1.57)

Table 1: Descriptive statistics for the cyan optical density

Factor	N	Mean	StDev	95% CI
SBS 12 point	50	1.28	0.02	(1.26, 1.29)
SBS 18 point	50	1.23	0.02	(1.22, 1.24)
SBS 30 point	50	1.28	0.04	(1.27, 1.29)
CRB 18 point	50	1.30	0.02	(129, 1.31)
Corrugated boards	50	1.28	0.03	(1.27 1.29)

Table 2: Descriptive statistics for the magenta optical density

Factor	N	Mean	StDev	95% CI
SBS 12 point	50	0.77	0.01	(0.76, 0.77)
SBS 18 point	50	0.76	0.01	(0.76, 0.77)
SBS 30 point	50	0.83	0.01	(0.83, 0.84)
CRB 18 point	50	0.81	0.01	(0.80, 0.81)
Corrugated boards	50	0.76	0.03	(0.75, 0.76)

Table 3: Descriptive statistics for the yellow optical density

Factor	N	Mean	StDev	95% CI
SBS 12 point	50	1.56	0.02	(1.55, 1.57)
SBS 18 point	50	1.87	0.02	(1.86, 1.88)
SBS 30 point	50	1.63	0.03	(1.62, 1.64)
CRB 18 point	50	1.73	0.02	(1.72, 1.74)
Corrugated boards	50	1.77	0.02	(1.76, 1.77)

Table 4: Descriptive statistics for the black optical density

Table 5 shows that the 12-point SBS paperboard produces a wider colour gamut. The 18-point CRB paperboard yields a smaller colour gamut. Overall, tested SBS paperboards produce wider colour gamut volumes, compared to 18-point CRB paperboard or corrugated board. However, 18-point CRB paperboard has smaller colour reproduction variability.

Factor	N	Mean	StDev	95% CI
SBS 12 point	50	281412	8485	(277699, 285124)
SBS 18 point	50	270686	5927	(266974, 274398)
SBS 30 point	50	276262	23975	(272550, 279974)
CRB 18 point	50	249494	1434	(245782, 253206)
Corrugated boards	50	250819	14281	(247107, 254531)

Table 5: Descriptive statistics for the colour gamut

4. Colour Reproduction Consistency and Process Capability Analysis

The following tools in the Minitab 16.0 software were used to analyze the consistency for optical density and colour gamut measurements: individual control charts, moving range charts, and capability analysis. The individual control charts and moving range charts were used to remove the outlier data. The capability analysis tool was used to calculate the Cp index for each paper type. In order to perform the capability analysis, lower specification limits (LSL) and upper specification limits (USL) are required input parameters. However, due to a lack of historical parameters of LSL and USL for colour-related attributes of paperboards and corrugated boards, relative specification limits were determined using test data. In this study, the LSL and USL for each attribute are determined based on the following procedures:

1. Construct the trial individual control chart and moving range chart of each attribute for the tested paperboards and corrugated board.

2. Examine control charts; if the data is in control, then use the lower control limit (LCL) and upper control limit (UCL) as the LSL and USL. If it is in out-of-control condition, reconstruct the control chart after eliminating all the outlier data in the

initial charts to obtain the revised values for mean, LCL, and UCL.

3. For each attribute, the difference between revised LCL and UCL of each paperboard/corrugated board obtained in the previous step is computed and named 6σ_revised, i.e., UCL_revised – LCL_revised = 6σ_revised. Then 3σ_revised of each paperboard/corrugated board is computed for the purpose of obtaining the "average 3σ_revised" of the four tested paperboards and one corrugated board, 3Ŝ_revised namely, i.e., 3Ŝ_revised = (3σ_revised_12-point SBS + 3σ_revised_18-point SBS + 3σ_revised_30-point SBS + 3σ_revised_18-point CRB + 3σ_revised_corrugated board) / 5

4. For each attribute, the final LSL and USL are obtained by subtracting from and adding to the 3Ŝ_revised, the revised mean of each paperboard/corrugated board, i.e.,
   LSL_final = Mean_revised – 3Ŝ_revised
   USL_final = Mean_revised + 3Ŝ_revised

5. The LSL_final and USL_final (as shown in Table 6) were used to assess the relative Process Capability Ratio (PCR) for the revised individual measurement control chart of each attribute for the tested paperboards and corrugated board.

Using LSLfinal and USL final values in Table 6, the relative Cp indices were calculated (as shown in Table 7). A higher Cp index indicates greater capability of delivering more consistent results in the printing process. As shown in Table 7, the corrugated board had the largest relative Cp index for optical density magenta (Cp = 1.35) and cyan (Cp = 1.32). The 12-point SBS paperboard had the largest relative Cp for the optical density yellow (Cp = 1.90), while 30-point SBS paperboard had the largest relative Cp for the optical density black (Cp = 1.90). It is interesting to note that the 18-point CRB paperboard had the largest relative Cp for the colour gamut (Cp = 2.69), followed by 12-point SBS (Cp = 2.48) and 18-point SBS (Cp = 2.23). That is, the 18-point CRB paperboard was the most capable paperboard for delivering consistent results in colour gamut. It was assumed that the tested 18-point CRB paperboard has a more uniform coating layer. The tested 12-point SBS and 18-point SBS paperboards also have capability for delivering consistent results in colour gamut.

		12 point SBS		18 point SBS		30 point SBS		18 point CRB		Corrugated	
		LSL	USL	LSL	USL	LSL	USL	LSL	USL	LSL	USL
Optical Density	Y	0.74	0.80	0.74	0.79	0.80	0.86	0.78	0.83	0.73	0.79
	M	1.21	1.34	1.17	1.29	1.22	1.34	1.24	1.36	1.23	1.35
	C	1.45	1.80	1.62	1.98	1.43	1.78	1.52	1.88	1.37	1.73
	K	1.49	1.63	1.80	1.94	1.57	1.70	1.66	1.80	1.70	1.83
Colour Gamut		271115	297192	259812	285889	274181	300258	236456	262533	237781	263858

Table 6: The LSL and USL for each attribute

		12 point SBS	18 point SBS	30 point SBS	18 point CRB	Corrugated
Optical Density	Y	**1.90**	0.95	1.68	0.85	0.61
	M	1.31	1.00	0.74	0.88	**1.35**
	C	0.85	0.91	1.16	0.91	**1.32**
	K	0.72	1.21	**1.26**	0.94	1.09
Colour Gamut		2.48	2.23	1.92	**2.69**	0.31

Table 7: The relative PCR (Cp) values for the tested paperboards and corrugated boards

5. Spot Colour Matching Analysis

Figure 3 illustrates the graphs of colour gamut with L*a*b* values of target spot colour data for the tested four paperboards and one corrugated board. Around 40-45% of Pantone spot colours are located within the colour gamut of tested paperboards and corrugated board. In other words, with limited colour gamut, those highly saturated spot colours will be difficult to be reproduced on those paperboards and corrugated board.

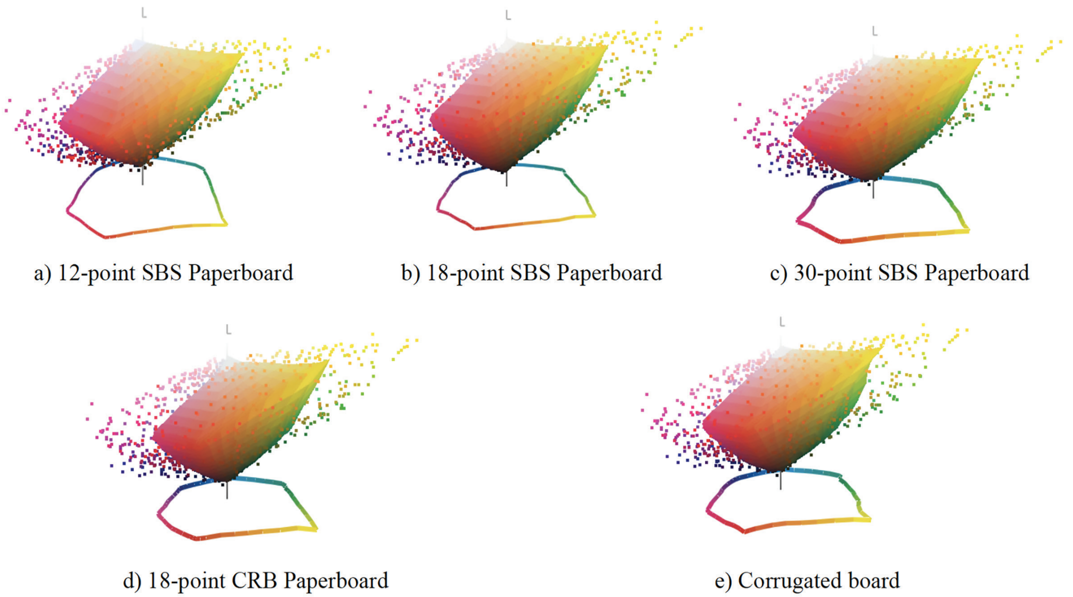


Figure 3: Colour Gamut of tested paperboards and corrugated boar (With L*a*b* values of spot colour original data for reference)

Figure 4 shows spot colour matching capability of tested paperboards and corrugated board. It shows that 30-point SBS paperboard can reproduce about 12% of Pantone spot colours with ΔE2000 lower than 4.0, while the 18-point SBS and 18-point CRB paperboards can only reproduce around 3% to 4.5% of Pantone spot colours with ΔE2000 lower than 4.0. Around 31% of Pantone spot colours can be reproduced with ΔE2000 lower than 8.0 when the 30-point SBS paperboard is used.

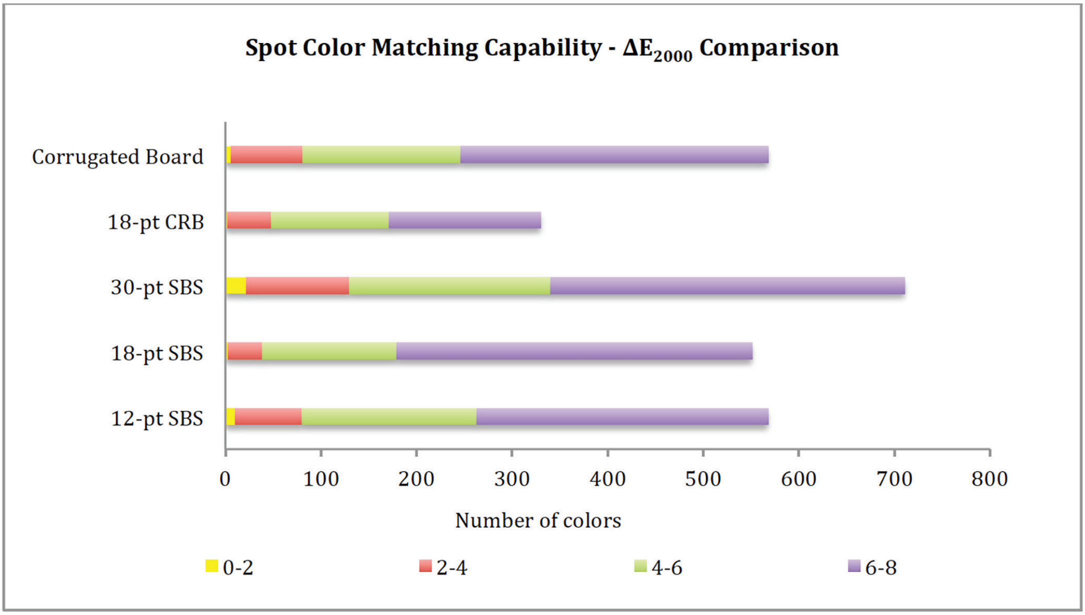
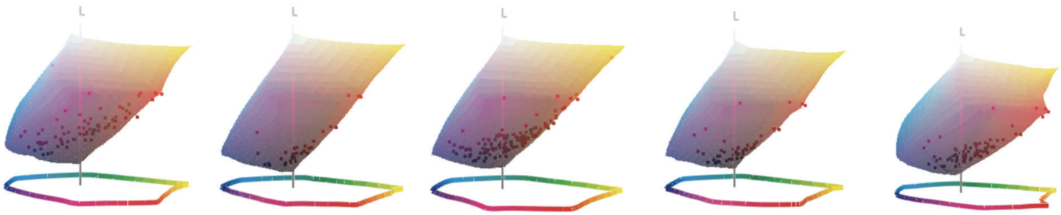


Figure 4: Spot colour matching capability for the teste paperboards and corrugated board



a) 12-point SBS Paperboard | b) 18-point SBS Paperboard | c) 30-point SBS Paperboard | d) 18-point CRB Paperboard | e) Corrugated board

Figure 5: Colour gamut of tested paperboards and corrugated board (with ΔE_{2000} lower than 4.0)

6. Conclusions

Colour consistency is a must in packaging. Brand colours must be spot on. Printed with standard CMYK ink systems, the colour gamut volumes of tested paperboard and corrugated board are in the range of 249,500 and 282,000. With small colour gamut produced on the tested paperboards and corrugated board, spot colour matching capability is limited. It was found that the 12-point SBS, 18-point SBS, and 18-point CRB paperboard were capable paperboards for delivering consistent results in colour gamut. Spot colours with ΔE2000 lower than 4.0 can be found in the lower portion of the colour gamut. Overall, it was found that 30-point SBS paperboard has better spot colour matching capability (with 12% of spot colours having ΔE2000 lower than 4.0). Further investigation will include possible testing on a UV ink-jet printer with extended ink systems to pursue a wider colour gamut.

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Identification of skills gap in cross-media design and production in the creative industries at EU-level

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1. Introduction

Skills identification in the industry and the educational system is nothing new. Over the last decade, it gained enormous momentum in light of structural changes that rocked the economy of the European Union. This prompted the EU to be more vigilant about its competitiveness vis-à-vis other continents, and about the possible effects of developments in information and communication technologies for our knowledge society. The transition from the industrial to the digital era requires the reskilling of people in Europe. In nearly seven years, the identification, analysis and forecasting of skills needs has become a key element of policies to improve the functioning of labour markets, the competitiveness of companies and the relevance of higher education. Higher Education Institutions (HEI) need to be conscious of new skills portfolios in order to shape educational programmes and ensure that graduates are 'future proof'. Future skill requirements and the need to specify them precisely have therefore been increasingly referred to in the framework of the EU Lisbon Strategy on growth and jobs, and other related policy documents thereafter, and have been subject to many researches and surveys. This report aims to gather the most relevant findings of these reports and will pay special attention to the context of partner countries of the Creative Industries Global Network (CIGN) project.

CIGN is a pan-European network for curricular development for the Creative Industries and will identify sectorial skills gaps, develop curricula to address these, and create opportunities for future employment to evolve during and after the proposed project.

ICT-driven approaches that grant access to education for everyone, that create learning communities beyond classrooms and that allows education for cross-media design and production across borders and languages are challenges that this project aims to tackle.

All partner institutions have a proven track record of cooperation on different levels of research, education management and programme development. In addition to established student and staff mobility programmes, the four European HEIs are collaborators in the InterCultural Design Camp (http://www.designcamp.eu), a EU-funded Summer School.

Although all partner institutions have a strong focus in educating students for the Creative Industries, each of the higher education institutions has a slightly different focus.

The partner institutions are:

- Artevelde University College Ghent, Belgium
- Linköping University, Sweden
- Ryerson University, Canada
- Stuttgart Media University, Germany
- University of the West of Scotland, UK

In the following pages, the report describes the transformation of the skills portfolio as the media design and production sector evolved into the creative industries. The functioning of sector councils in Europe will highlight this, as a means to come to a more structural and concerted approach in assessing skills needs involving all of the relevant stakeholders. Special attention will be given to the latest and most relevant EU-policy and research papers related to media design and production.

A separate report will examine how the national authorities and stakeholders of the five project partners respond to this issue. It is not the aim of the report to present an exhaustive list of reports and research documents on the above issues, thus the selection will focus on the reports with the most relevance and pertinence for the overall CIGN project goals. As this report is the result of a collaborative effort, the name of the author of the initial draft has been placed first, the names of the other partners follow alphabetically.

2. Background on the transformation of the sector

The lack of information on future skills needs and newly emerging skills has been a long-standing concern in Europe. This is true for all economic sectors but especially for the domain of information and communication technology. This should be no surprise given technological innovations and their insinuation into changing consumer preferences. The present situation in the media industry is characterized by the speed with which compelling changes are taking place in the Creative Industries due to - amongst other things - new applications, new consumer needs, new target groups, new business models, as well as aspirations and expectations. Driven by these changes, completely new industries have arisen (such as computer games and web design), and traditional consumer industries have been forced to redesign and repackage their offerings to suit consumers' desires.

The prospect for innovations requires a quick response to be effective and does not stop to impose challenges and infuse opportunities to the sector. In turn, due to their structural character, changes bear a forceful weight on the need to swiftly adapt the skills portfolio of the existing and future workforces. Companies that have not taken the time or lacked the resources to restructure, to revamp their businesses, to invest in their existing workforce or attract new skills, often did not survive the constant transformation of the sector. As a result, new functional and professional profiles are often already (long) in existence before they are formally defined by official bodies established to document and describe the skills of these new profiles.

Over the last decade, the EU authorised a number of studies to analyse the European economy and the creative industries in particular, especially its competitiveness and prospects to respond to recent structural and technological challenges in an open market context (e.g. [1], [2] and [3]). One of the major findings of these reports related to the transformation of this sector over the last two decades. Digitalisation and Information and Communications Technology (ICT) developments have completely transformed production processes and their output potential. Advances in technology, business models, communications strategies, and consumer needs have led many graphic communications companies to broaden their services to become 'one-stop-shops' for marketing, design, print and non-print media production, as well as database management services. As a result, the old denomination 'print media' is out-dated and 'cross-media design and production' is more representative of an emerging sub-sectorial focus within the Creative Industries in Europe.
The digitalisation of communication and the emergence of the Internet furthered the convergence of freestanding media (radio, television and print) that once stood alone. Recently, various economic sectors, concerned with creation or exploitation of knowledge and information, saw fit to group and adopt a new name, the 'creative industries' or 'creative and digital industries'. Also organizations, companies and institutions active in the field of cross media design and production increasingly adopted this new appellation and approach.

Creativity is increasingly perceived as a strategic driver for economic growth and a real asset for improving competitiveness in a knowledge-based economy (http://www.access-to-culture.eu/accesstoculture/14/calendar/?calendar_id=56) [4]. The Creative Industries are knowledge and labour intensive and foster innovation, so the sector is perceived to have a huge but largely untapped potential for generation of employment and export expansion [4]. This offers both an opportunity and a challenge as the technological landscape is not remotely stable but is changing at mindboggling speed and employee skills will have to evolve along with it. This increases the pressure on an already complex society as it attempts to come to grips with the opportunities of today's technology while simultaneously addressing the need to prepare for tomorrow's technological innovations.

2.1 The emergence of the Creative Industries in Europe

This report is not about collating definitions or delineating a broadly or academically acceptable definition of the Creative Industries or the Creative Cultural Industries, but how skills identification is taking place within this new concept. Some common ground and acceptable description of this sector is required in order to better understand and contextualize today's reality of crossmedia design and production. Although not a single definition of the Creative Industries is widely accepted, all agree that it is a key component in the new knowledge economy. For the sake of this report, the authors adopted Hawkins' definition of the creative economy encompassing advertising, architecture, art, crafts, design, fashion, film, music, performing arts, publishing, R&D, software, toys and games, TV and radio, and video games [5].

Within the EU, the formal origins of the concept of Creative Industries [6] can be found in the decision in 1997 by the newly elected British Labour government to establish a Creative Industries Task Force (CITF), as a central activity of its new Department of Culture, Media and Sport (DCMS). The Creative Industries Task Force set about mapping current activity in those sectors deemed to be a part of the UK Creative Industries, measuring their contribution to Britain's overall economic performance and identifying policy measures that promoted their further development. The Creative Industries Mapping Document, produced by the UK DCMS in 1998, identified the creative industries as constituting a large and growing component of the UK economy. The UK Creative Industries Mapping Document defined the Creative Industries as *'those activities which have their origin in individual creativity, skill and talent and which have the potential for wealth and job creation through the generation and exploitation of intellectual property'* [7].

As a consequence of this delineation, the Creative Industries sector includes a variety of business, including many types of enterprises, from large-scale enterprises (LSE) and multi-national corporations, to areas of activity in which small and medium enterprises, (SME) are predominant. As is the case with media design and production companies, SMEs make up the majority of the creative industries sector as a whole. According to a recent study on the Entrepreneurial Dimension of the Cultural and Creative Industries, 80% of enterprises in the sector are SMEs with many being sole proprietorships or micro-SMEs [8]. As such, a report dealing with skills identification in cross-media design and production also reflects the profound transformation of the sector over the last two decades. This report identified how expertise in the production and distribution of various, autonomous media (print, TV and radio) took advantage of technological developments and opportunities to converge and identify crossovers in order to complement and reinforce each other. For many Higher Education Institutions it all started with a background in ICT or media production. In the case of the CIGN project partners, the latter meant print media. Now, the partners are all part of a much larger domain: the creative industries. As such, an overview of various successive studies and policy documents constitutes a reflection of a sector in transition and transformation.

In recent years, creative industries have become increasingly attractive to governments outside the EU and the developed world. In 2005, the United Nations Conference on Trade and Development (UNCTAD) XI High Level Panel on Creative Industries and Development commissioned several studies to identify challenges and opportunities facing the growth and development of creative industries in developing countries. The creative industries have shown increasingly their relevance to economic well being, underscoring that *'human creativity is the ultimate economic resource'* [9] and that *'the industries of the twenty-first century will depend increasingly on the generation of knowledge through creativity and innovation'* [10].

2.2 The establishment and operation of Sector Skills Councils in the European Union

Evaluating relevant reports and policy papers provided a privileged look at how initially ascertaining future skills needs for manpower planning in certain companies/sectors, evolved into a more general assessment of skills needs to inform all stakeholders, including HEIs.

2.2.1 Investing in the Future of Jobs and Skills

Ensuring the availability of appropriate skills and competences is imperative for the future of competitive European creative industries[1] . To ensure a better match between the skills supply and labour market demands for qualified manpower, the EU undertook major research in 2007. A total of sixteen sectors were selected and studied from 2007 onwards, one of them being the printing and publishing sector [11]. The final results of this comprehensive analysis of emerging competences and economic activity in the printing and publishing sector were published in the report, 'Investing in the Future of Jobs and Skills' [12].

This thorough report analysed sectorial trends and developments in print and publishing combining secondary research and expert information to present a number of options and recommendations to tackle future skills and knowledge needs in the publishing and printing sector. By adopting a uniform methodology for all sixteen sectors[2] , the total package of sixteen studies allowed policy makers to adopt human resources and management strategies and to devise mechanisms for better and more effective interaction between innovation, skills development and job creation.

Content

The actual report on the printing and publishing sector features three major parts followed by a series of recommendations. Part I provides a thoughtful and concise overview of the sector including current developments and trends. This serves as a basis for Part II, where statistical data is probed and extrapolated to construct four potential scenarios for the printing and publishing sector and implications for desired competences in various job functions. In the third part, the report describes the main strategic options to meet the identified skills and knowledge needs. The report concludes with a set of recommendations for policy makers, sector representatives and education and training institutes. The advice and conclusions were discussed during a final workshop with representation from social partners, the industry and other experts.

Recommendations

Most of the recommendations are addressed principally to vocational education and training programmes and aimed toward changes at national rather than international levels. Clearly, the most important recommendation for all education and training institutions is to keep up with the changes in skills needs. This does not limit itself to technological developments, but also refers to the management of an ageing and shrinking workforce, changes in consumption patterns and customer demands, and the emergence of new business models. The convergence of technologies and markets make inter- and multidisciplinary competences a key asset to enable prompt adaptation to these changes. Soft skills (languages, (self-) management skills, problem solving skills, an inclination to lifelong learning and innovation, and entrepreneurships) will increasingly gain importance in all job functions but especially for highly skilled professions, although technical skills remain indispensable. Emerging competences of higher skilled jobs will attach greater importance to how to learn, how to communicate, how to interact with colleagues and customers, as well as how to adapt to changing environments in addition to continuous performance in high quality education.
Due to the prevalence of SME's in the sector with their limited resources for upskilling and retraining of their staff, training facilities must be sought external-

[1] This chapter is partly based on Bouters, Luk, New skills for the printing industry appeal for new approaches in education, International Circular of Graphic Education and Research, No. 4, 2011, p.58-61.

ly. Some recommendations therefore call for more flexible and less formal training forms, including promoting e-learning and modularisation, and supporting the establishment of regional training networks in order to make the latest equipment available to a larger group of training providers. A better flow of information between the industry and the training institutions on new skills and knowledge needs should bridge existing and future gaps and should steer career and training guidance for employees. Based on the findings of the sixteen reports, some general conclusions may be drawn. All sectors will increasingly be forced to focus on more flexible communication with customers, a higher degree of flexibility in satisfying customer needs, and an increased need to use on-line technologies. Further, the report stresses the importance of good communication skills, problem-solving skills and analytical skills. With regards to entrepreneurial skills, the reports highlight the importance of understanding customers and process optimizing skills. However, the largest increase in importance was found to be a high level of flexibility and also stress and time management.

Remarks

Most (if not all) of these recommendations elicit a 'déjà vu' effect. The major benefit of this list of recommendations, lies in the very fact that they are grouped and, based on recent data and experience, underscoring again the same major points and possible solutions. The results and recommendations from the studies are intended to form a useful guide for the attention of European, national and regional educators and administrators enabling them to qualify and substantiate their choices and actions to promote stronger synergies between innovation, skills and employment.

The production context for print media companies has since the time of the study not changed that much and the problems identified remain the same, illustrating the inability of the sector to pursue collective action plans. The latter is due to the fact that the sector consists mainly of relatively small companies.

In the end, the Executive Summary [13] petitions for collaboration and joint actions by all stakeholders in order to address future skills and knowledge needs and to agree on and implement a package of feasible solutions. With little or no supplementary resources at national levels to finance such ventures, it remains doubtful whether this colloquial language will be sufficient to meet this noble appeal at all levels intended. This is especially so when recommendations such as modularisation, e-learning packages or individual career guidance require considerable additional (human) resources that are presently non-existent.

2.2.2 New Skills for New Jobs: Action Now

Context

A second key report, 'New skills for New Jobs' [14], is a EU policy initiative to meet the recommendations expressed in the previously discussed Investing in the Future of Jobs and Skills (2009) report and aims at achieving a better match between labour market needs and available skills. In 2009 a group of experts was asked to provide independent advice about how to proceed and accomplish the EU's future strategy, Horizon 2020[3] [15].

Content

This report principally focuses on the desired key actions to ensure that a qualified work force is in place to meet the requirements of tomorrow's labour market and to cope with the challenges of global competition. The need to anticipate changing skills needs in a regular, systematic and consistent manner across the whole of Europe and to better align skills demand and supply has now been recognized.
The report draws attention to the practical steps

[2] The report provided a methodology to improve the capacity of the EU Member States to assess and anticipate future skills need of employers and employees in the print media industry. This methodological framework was initially developed by Maria Joao Rodrigues (2007) and commissioned under the European Community Programme for Employment and Social Responsibility – PROGRESS (2007-2013).

[3] Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness.

that need to be taken in education and training to provide citizens with better opportunities to succeed in the labour market [16]. Better formal and informal education is believed to be the right answer. For this purpose four major, complementary recommendations were developed. The authors make it clear from the outset: future prosperity will depend greatly on how successful Europe becomes at broadening and raising skills levels of its future workforce. The central role of education and training institutes and the prerequisite of increased investment in education to achieve this ambition is crystal clear.

Recommendations

In the report a number of the key actions are identified:

1. Provide the right incentives to upgrade and better use skills for individuals and employers.
2. Bring the worlds of education, training and employment closer together.
3. Develop the right mix of skills.
4. Better anticipate future skills needs.

These recommendations contain valuable and interesting policy views and advice. These include the first group of recommendations where the report pleads in favour of better defining curricular standards, including the learning outcomes [17], and the various mechanisms of quality assessment and evaluation deployed in an educational context.

The second recommendation calls for a more substantial and intensive relationship between skills providers and employers in order to ensure that people receive the most appropriate qualifications and understand from the very start what is expected from them at the end of the learning pathway. To this end, a European qualifications framework, including outcome-based qualifications, should be developed. These learning outcomes should be based on labour market needs analyses and their introduction should be supported by appropriate pedagogy and assessment methods. This process requires the commitment of all, especially political leaders, and needs to be carried out by all stakeholders including educational institutes, employers' organisations and trade unions. These key recommendations end with a call to open up the learning groups to encompass a larger audience, including vulnerable groups and adults with or without prior work experience.

The third recommendation stresses the need for soft and more generic competences in addition to the technical skills required for a specific function. Apart from e-skills and digital fluency, higher education should embed key enabling competences such as creativity, innovation, entrepreneurship and citizenship. To monitor this process, education providers require quantitative targets. This endeavour asks for an appropriate learning environment involving consistency between learning outcomes, assessments, methodologies applied and the teaching corps deployed. Obviously, this novel paradigm of practice-oriented curricula might entail a review of the present curricula for teachers' education to ensure education professionals graduate with the appropriate skills and practical experience.

The last cluster of recommendations draws attention to the necessary development of early warning and matching systems to better anticipate future skills needs. Aggregating national and supra-national intelligence through various surveys will be key to develop measuring tools to pinpoint and foresee skills gaps, shortages, surpluses, as well as over- and under-education. Through the development of comprehensive tracking systems, learners' success in the labour market can be monitored and the delivery capacity of educational institutions assessed. The fourth recommendation ends with a call to '*create EU sectorial councils, bringing together existing national networks at EU level for the analysis of the skills needs and the development of proposals for updated qualifications in each sector*'.

This report and its recommendations, paved the way for a pan-European follow-up project aiming at establishing sector councils to strengthen collaboration between industry, social partners, and the educational and training institutions.

2.2.3 Sector Skills Councils on Employment and Skills at EU level. A study into their feasibility and potential impact

Context

Training and skills sit at the heart of any agile economy. A society can only be as economically innovative and effective as the skillsets of its populations allow. It is the responsibility of policymakers and educators to create programs to tackle the skills demand systematically [19]. Sector skills councils are platforms where stakeholders seek to gain insight into likely developments in employment and skills needs, with the aim of assisting policy making within or for this sector. Transversal councils are similar to sector councils, but cover trends and developments in two or more sectors of the labour market. In 2010, 27 country reports were published introducing and portraying various existing Sector Skills Councils in the EU [20]. The 22 states surveyed feature a great variety of different bodies working on skills at national and sectorial levels in order to provide information to different stakeholders.

In pursuance of a recommendation formulated in the report mentioned above (cf. [12]), the EU commissioned a study to examine the feasibility of establishing more uniform sector councils. With this decisive step the EU wanted to institute a structural and coordinated dialogue in as many sectors as possible with a view to:

- Acquire a deeper understanding of skill needs at the sectorial level,
- Contribute more effectively to the development of skills governance at the sectorial level and of national skills policies by facilitating capacity building and peer-learning amongst national skill observatories or equivalent organizations,
- And to foster intersectorial collaboration by creating a European platform of exchange and development of joint sectorial skills projects.

Such Councils could be composed of key stakeholders of a particular economic sector including representatives from trade unions and employer organizations, members of education and training systems as well as other relevant actors involved in economic development.

Content

In total 44 different councils were identified in 22 member European Union countries, leaving five countries without sector skills councils. The main reason for the latter is that in certain member countries (e.g. Germany) bodies other than sector councils operate to link the world of work to the world of training thus adding to the great variety of different bodies dealing will skills identification. The fact that so many member countries have councils signifies the importance member countries pay to optimizing skills training in their initial and continuing education systems. Five sectors were selected for a more in-depth study of the feasibility. The final selection included sectors for hotels, restaurants and cafés, construction, ICT, textiles and clothing, and hospitals.

A very important finding was that there were more transversal than sector councils. These councils deal with a series of sectors concurrently. The reason for this is assumed to lie in the organizational model adopted by small states (such as Luxembourg) and in the fact that countries with a sectorial model simultaneously have umbrella transversal councils to discuss issues of common interest. Next to national councils, in a limited number of member states, councils with regional responsibility, mainly with a transversal scope, exist. This could be in initial and/or continuing education.

International co-operation between sector skills councils is rare, but the respondents to the survey expect EU level Sector Councils to boost the effectiveness of national councils and to have a positive impact on the responsiveness of education systems to future labour market needs.

Establishing institutional frameworks to monitor and analyse changing skills needs (both quantitatively and qualitatively) are important elements in the prevention of market failures. Government policy makers and expert groups both at an academic or consultancy level still mainly tap this labour market intelligence. This report advocates making such information available to all labour market participants.

This report highlights the fact that various forms of cooperation and partnership exist and connect different bodies (ministries, employers, trade unions, and education providers) and channels labour market information into the education sector. 'Some countries have also opted for the direct regulation of education and training supply based on employment forecasts. Furthermore, many countries have implemented quality assurance mechanisms that allow for performance monitoring and feedback. Finally, virtually all European countries are in the process of establishing qualification frameworks that provide additional mechanisms to link education and training provision with labour market requirements' [22].

Recommendations/observations

Most countries have some kind of system for skills forecasting, but they vary greatly and are to a large extent determined by the existing statistical infrastructure and the country's history in approaching this issue. Unsurprisingly, the creative industry sectors are still very young and diverse, and some of components are of a recent origin while others are longs-standing economic sectors such as the printing industry with well-established networks and research institutes.

There has been a general shift in the objectives of these councils. From identifying future skill needs for manpower planning, to developing an institutionalized process of detecting the required skill portfolios and opening this information up for all stakeholders, including HEIs. Indeed, with regards to media design and production, only recently have the specialized HEIs and their international networks been more actively and systematically involved in this process. Given the variety and complexity of existing systems, there is a clear desire to come to a more uniform approach but especially to make the data available more accessible and exchangeable. '*The case for a pan-European system for skill needs anticipation is generally accepted and the Cedefop work has begun to fill this gap. But much more remains to be done, although various initiatives are in place to move things forward, including the EU Skills Panorama*' [23].

The various approaches to tackle the issue of skills identification in EU's creative sector are an example of this. Although a lot of research has taken place to gather data on the sector's composition and economic value. Little has happened to bring all the stakeholders from the various sectors together in one single forum to identify new competences. This is largely explained by the broad nature of the creative sector and the histories of the respective participants.

It was observed that the objectives envisaged within the scope of study show overlap with existing EU initiatives such as the European Qualifications Framework (EQF) the European Credit Transfer and Accumulation System (ECTS) and the European Credit System for Vocational Education and Training (ECVET). The report therefore recommends attuning and a good exchange of information between these institutions. On the other hand, it was felt that a strong sectorial focus would make intensive cooperation useful, such as the restructuring forums. With regard to the European Social Dialogue at sector level, it was recommended to focus on information exchanges and to avoid discussions on social issues. Intensive cooperation with the European Centre for the Development of Vocational Training (Cedefop) initiatives for forecasting and anticipation tools (such as the European Monitoring Centre on Change) and the sectorial studies commissioned by DG Employment was also advised.

The study also revealed a strong interest from the education sector to determine future employment skills needs and to dialogue with the social partners on future needs. The study therefore suggests that the councils to be should also encourage involvement of the education and training sector, as well as to align future labour market demands with education supply. To this end, the study advises the inclusion of a representative from the HEIs in the various councils.

2.2.4 New Skills for New Jobs. Policy initiatives in the field of education: Short overview of the current situation in Europe

Context

This research report [24] is a follow-up of the initiative 'New Skills for New Jobs' (see above) and aims to promote an improvement in skills forecasting and matching the supply of skills to the needs of the labour market through improved collaboration between the market and education.

Content

The summary report is composed of four sections. 'The first section focuses on recent national initiatives in the area of forecasting and matching skills with the demands of employers. It looks at the development of methods, approaches and tools for forecasting the skills that will be required, and it provides examples of the range of measures taken to ensure that available human resources match labour market needs. The second section provides information on the institutional mechanisms required to forecast and address the demand for skills. This includes arrangements to ensure that the results of work on the identification and analysis of skills is fed into the planning and design of education and training systems. The third section offers concrete examples of policy initiatives and education reforms introduced in response to labour market needs. This section illustrates current European trends in skills, competences and learning outcomes in various aspects such as curriculum design, teacher training and assessment. The final section focuses on the impact of the recent economic crisis on education systems and on the transition of young people from school to the labour market.' [25]

Conclusions

Most countries rely on their own institutional mechanisms to ensure that labour market information is fed into the planning and delivery of education and training. To do this, a variety of different forms of cooperation and partnership exist and are deployed to connect different stakeholders (ministries, employers, trade unions, and education providers) and provide the education sector with labour market information. Many countries have established national quality enhancement mechanisms that allow for performance monitoring, accreditation and feedback. All European countries are in the process of establishing qualification frameworks that provide additional mechanisms to link education and training provision with labour market requirements often in concordance with the supranational EQF.

The policies, strategies and reforms in education intended to reinforce responsiveness to labour market needs, take a variety of forms ranging from comprehensive measures to more targeted approaches. Comprehensive strategies connecting education and training to the labour market cover the following main areas including curriculum reform, education and training of teachers and trainers, student assessment, and quality management [26].

The report noted a striking difference in approach between the vocational training sector and the higher education sectors. The former has been subject to more comprehensive, consistent and strategic reforms. With regards to higher education, the reforms are more disparate and limited to specific sectors of the economy and comprehensive reforms are therefore rare.

It is noted again that several countries took significant steps to implement a more flexible and transparent transition between the different levels and segments of education, especially between vocational and non-vocational paths. There has also been a general shift towards skills and competence-based frameworks in education and training provision at all levels. Furthermore, internships and apprenticeships have been introduced and have seen their program weight increasing both in vocational and higher education settings.

A final significant but not unexpected outcome of the research project was that, in recent years, education-decision makers have become more responsive and sensitive to economic changes and labour market needs due to the economic crisis.

2.2.5 Future Skills in the Graphical Industry

Context
This project [27] is a follow-up on the recommendations formulated in the previous two reports and was executed in the context of the European Social Dialogue policy and programme. The New Skills for New Jobs agenda stressed the need to anticipate the ever-changing skill needs and consequences for training and education providers. The rationale for timely anticipation was elaborated in a report [28] published by the Warwick Institute for Employment Research commissioned by the Cedefop. The final report of the project 'Future Skills in the Graphical Industry. Identifying and promoting best practices in Europe' was presented at a closing conference in Berlin (October 2014) and attended by two partners of the CIGN-project.

Content
This project, commissioned by the EU and initiated by Intergraf and UNI[4], aims at establishing the crucial stages of the skills identification process and of the training solutions deployed. The above report does not describe current educational frameworks or existing national procedures or practices in use for the design of new educational programmes. It does, however, have a prime focus on the lower Vocational Education and Training (VET) institutes although a number HEIs contributed to the survey.

The survey adopted a dual approach. Following secondary research on the present situation of the industry and VET education across Europe, it describes the best practices adopted to introduce new skills training. To do this, the researchers distinguished the traditional printing industry from what they called 'the new media and digital industry'. According to their findings, VET schools took the lead in identifying entirely new job profiles, while the industry took the lead in strengthening skills in more traditional roles. Not surprisingly, the role of the social partners was more present in the latter. Case studies highlighted the fact that it could take up to three years of response time before a new educational programme was formally accepted and the course was finally up and running. VET schools specially react more slowly when it came to introducing new educational programmes than adult training courses. This is mainly due to formal (government) regulations and procedures. Following four case studies from the UK, the Netherlands, Spain and Malta, different scenarios for skills development are presented. The survey then describes the best practices for identification and development of skills in courses for vocational education. The survey shows that businesses on the cutting edge pursue their own training policy and do not depend on or rely on the formal education system or the availability of training programmes to instil new skills. In addition, the majority of the businesses 'go with the flow' and follow the path set by their competitors to delineate their skills training programme.

Recommendations

The recommendations formulated within the framework of this survey were summarised as follows:

- Social partner-guided VET development works well in the traditional industry but is less suited, in its current form, to the faster moving "new media"; involving different and evolving networks to be implemented in the processes;
- VET schools, employers and trade unions have a joint responsibility and interest in an "early warning" role in technology/skills changes;
- Employers at the leading edge of the industry should be supported at EU and national government levels as pathfinders in new skill development.

[4] UNI Global Union, represents more than 20 million workers from over 900 trade unions in the fastest growing sectors in the world, including graphical and packaging.
http://www.uniglobalunion.org/about-us

Comments

The description of the best practices for new skills identification and course development is solely based on and derived from existing practices in EU member states and refers to successful new training packages for lower VET.

3. Some concluding remarks

This CIGN report on the process of identifying new skills evaluated the increasingly vital link between shifting technological trends, labour market activity and the skills demands.

The findings are very timely and meaningful as our society attempts to come to grips with the opportunities of today's technology while simultaneously addressing the need to prepare for tomorrow's technological innovations. For HEIs, this complex situation is very challenging as new functional and professional profiles are often already (long) in existence before the inherent skills are formally defined by the current official bodies.

The question of up-skilling the workforce became central when researches outlined how Europe's competitiveness became at risk. The impact of the economic crisis and subsequent recession has been severe and the future for the labour market in Europe remains quite uncertain. Today, even after years of recession, it is clear that it is not possible to predict the future precisely. Despite this, many broad trends continue, in particular the shift towards a more knowledge-based, automated and service-oriented economy. The availability of reliable and sufficient intelligence for decision-making on the appropriate skills remains crucial and can help the European HEI sector to develop future curricula.

This report also describes the transformation of the skills portfolio as this sector evolved into the creative industries's. Generally speaking, the successive changes in consumer trends and technology, the European Union's policy and that of the national governments to foster a knowledge society and economic growth, combined with young people's desire to invest more in their personal development, have fuelled the importance of more generic competences. These include flexibility, entrepreneurship, personal and professional autonomy, and a willingness to attain continued professionalization. Sectorial and technological change will have significant implications for skills. But it is not all in favour of high-level skills; a demand for lower technical skills levels remains in areas where it is not possible to automate and where artisanal production methods exist.

Today, most countries have anticipatory measures in place and others are building and developing systems for skills forecast. Diversity still rules, but all have one common objective: to improve the match between labour demand and supply. There is, however, a growing demand and petition for anticipation systems at pan-European level to deliver comparable data on future (skills) challenges across Europe. The EU is speeding up efforts to come to a more standardized, structural and uniform approach through the establishment of (trans)national councils. The implementation of the EU's policy recommendations and action plans remains the most difficult point. There are a number of European Commission's programs such as ERASMUS+ which provide support to translate and turn policy into practice. This will help a lot but is clearly not sufficient to deal with the challenges lying ahead.
These funds are made available to support the development of the education and training sector across Europe. This includes networking, knowledge sharing and exchange of good practices to build a more agile and responsive educational system.

As HEIs and other training institutions are gearing up to better respond to the skills demands from industry and to the personal preference of students for new media applications, the supply of formal qualifications is also rising rapidly. Not withstanding this, the development of new training programmes takes time and resources. But when the available qualifications lag too far behind, companies react quickly and take the lead in developing further training of their staff themselves. Professional development through on the job-training and on-line learning might provide an adequate answer to the former. But education is not just only about employment and jobs, it is also about people taking their lives in their own hands and shaping their future.

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Teaching Considerate Colour design for people with colour-defective vision

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Keywords: colour-defective vision; designing for colour-defective readers, considerate colour design, deuteranopia

Abstract:

Graphic designers with normal colour vision often make the mistake of creating works that cannot be interpreted correctly by people with colour defective vision (a condition often called "colour blindness").
Though most designers and the teachers who instruct them in design are aware, the selection of colour in design must be both an aesthetic and a practical process. The practical part must include consideration of the small but significant percentage of people who do not see colour normally. This essay describes practical techniques for choosing colour palettes that will deliver successful designs that are also effective for colour-defective viewers.

1. Background

Human vision is a complex topic, and a subject on which a tremendous amount has been written. There are two general fields of research on human vision: the study and understanding of how the human eye works – chemically, physiologically, and biologically, and the observational study of how humans see.

Within the field of observational study is the topic of colour-defective vision. Researchers have developed an accurate understanding of the numerous genetically-caused defects found in human vision, and have mapped both normal human colour perception and a range of colour defects. (Kalmus, 1965)

In general, there are six types of colour-defective vision: red-green, green-red and blue. One additional type is achromatopsia, where there is no colour sensation at all. The six primary defects are described with different word suffixes: opia and omaly. Those defects ending with opia – deuteranopia, protanopia and tritanopia – describe people whose eyes lack colour sensors (cones) of a specific sensitivity. Those defects ending with omaly – deuteranomaly, protanomaly and tritanomaly – describe people with colour sensors, but whose sensors are defective. These defective sensors vary significantly from a very small degree of insensitivity to total insensitivity. This explains how some people have a mild form of colour-defective vision while others have severe colour-defective vision. (Jenny, Kelso, 2007)

People without any colour defects are called normal by all of the researchers cited in this study. Normal describes approximately 90 percent of the human population.

Color Vision	Cones	Percentage Affected
Normal	Normal	≈ 90%
Deuteranopia	Green absent	1% Males; <1.0% Females
Deuteranomaly	Green *defective*	6.0% Males; 0.4% Females
Protanopia	Red absent	1.0% Males; <1.0% Females
Protanomaly	Red *defective*	1.0 % Males; 0.01% Females
Tritanopia	Blue absent	<1.0% Males and Females
Tritanomaly	Blue *defective*	0.01% Male; 0.01% Females
Achromatopsia	No color sensitivity	<0.001% Male; <0.001% Female

Figure 1: Chart of Colour Defects
This chart describes the seven colour defects in human vision. All of these are caused by genetic mutation. For this essay, only the two marked in tan are considered because they represent the largest percentage of the population affected by genetic colour defects. (From Kalloniatis et al. "The Perception of Colour" 2007 and Kolb et al., 2007)

These seven variations are called as a group colour-defective vision. People with these visual characteristics are referred to as being colour-defective, while those whose vision is normal are called normal. People with either deuteranopia or deuteranomaly are together referred to as deuteranopic in this essay.

This essay addresses only the most common of the colour defective anomalies: deuteranopia and deuteranomaly. Colours selected using these techniques are also effective for the second-most common colour defective condition: protanopia. These techniques may be effective for tritanopic viewers, but that is not the focus of this study.

2. What deuteranopic people see

People with this form of red-green colour-defective vision see colours in the red-green spectrum as a tonally-varied arc of greenish colours. For these people, there is almost no difference between the extremes of red and green, and there is no red, orange or magenta in their spectrum of colour vision.

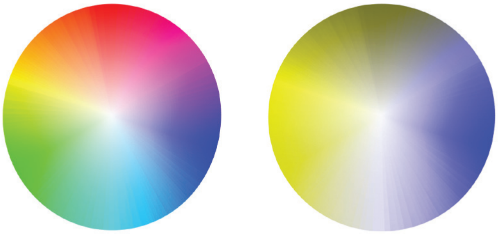

Figure 2: The spectrum of colours seen by a person with normal vision, left, and the colours visible to a person with deuteranopic vision, right. Note that the range of hues is limited to yellow-green on the lower-left to gray-green on the top-center. This creates a severe limitation of the colours that can be used for graphic design when catering to people with deuteranopic colour-defective vision. (Illustrations by the author)

The challenge for educators in the graphic arts is to help students understand the importance of designing with colours that can be seen by people whose vision is abnormal. This is especially true when the colours used in a design convey the information value of the product.

An excellent example of this is a public transit map showing the routes taken by buses combined with bus stops. A person with normal colour vision will be able to differentiate the routes easily. But a person with deuteranopic colour vision may not see a difference between the colours, and thus be unable to differentiate the routes and stops. (Jenny, Kelso, 2007)

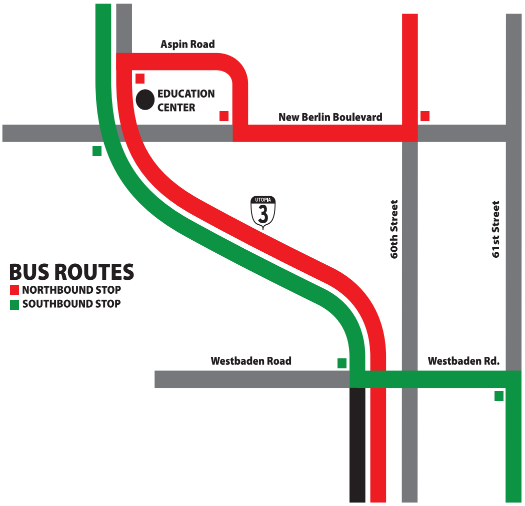

Figure 3: The map above shows two routes of a public transportation system. To a person with normal vision the red and green route lines are clearly visible and easy to differentiate. (Illustration by the author, 2016)

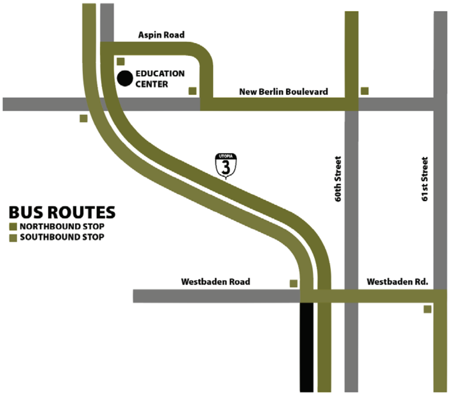

Figure 4: The same transportation map as seen by a person with deuteranopic vision. About six percent of males, and a smaller percentage of female viewers cannot differentiate the two bus routes. (Illustration by the author, 2016)

The transit maps shown in figures 3 and 4 illustrate the problem. How can we design the same transportation map using colours that do not confuse more than six percent of the population?
To become more effective in teaching graphic design, and colour design specifically, it is important for teachers to explain and demonstrate how people with colour-defective vision see colours. There are three effective tools for demonstrating colour vision deficiencies on a computer display.

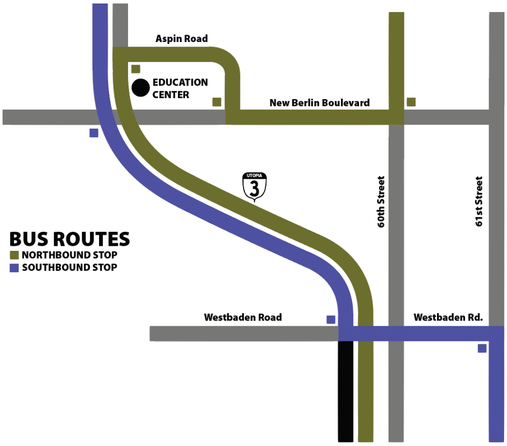

Figure 5: This version of the same map uses colours that can be seen effectively by people with normal colour vision, and by those with deuteranopic vision. Its colours were selected with consideration for the red-green weakness of the deuteranopic viewer (see also Figures 9 and 10). (Illustration by the author, 2016)

The first two are Adobe Photoshop and Adobe Illustrator, both of which feature a tool for previewing colours for the two most common types of colour-defective vision. The third is a stand-alone application called Colour Oracle. All are helpful in visualizing the challenge of design for colour-defective viewers (See "Simulating how colour is seen by colour-defective viewers" later in this essay).

More importantly, it is critically important for educators to understand the underlying concepts of colour-defective vision, and to be able to address these concepts in the classroom. Many people do not realize the challenges faced by those with colour-defective vision. To be able to simulate the view that these people experience when looking at print and electronic graphics is a valuable tool for the teacher of graphic design. It helps design students to understand the impact of their colour choices on the viewer, and it creates an environment where designers are considerate of their fellow man who cannot always see colour the way that people with normal vision see colour.

3. Does designing for the colour-defective ruin graphic design?

Designers can be offended by the idea that they should (or must) modify their colour palettes to accommodate a small percentage of the population. Occasionally one hears a complaint that designing with colour in this way is a form of unnecessary political correctness. However, this accommodation is not necessary for every product. However, when colour itself is the element of communication – as is the case with maps and infographics – then the colours chosen for the design must be visible to the entire population of viewers. Colour used in other ways – such as accents, backgrounds, etc. – does not need to be chosen with such care.

4. Confusion lines

In his essay Research on Normal and Defective Colour Vision (1946), W.D. Wright illustrates an arbitrary number of 27 confusion lines superimposed on a Chromaticity chart. These lines show how a person with deuteranopic colour vision will confuse a series of colours that cross the Chromaticity chart laterally from the green-blue axis to the blue-red axis. Researchers have accepted and expanded the concepts of these confusion lines in many research papers since. (Pirenne, 1967)

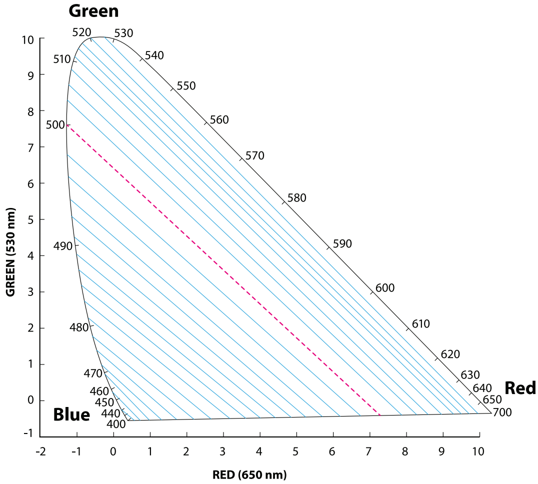

Figure 6: Deuteranopic confusion lines, as described by W.D. Wright in his 1946 essay on defective colour vision. Choosing two colours along any of these lines will result in confusion in the red-green colour-defective viewer. The red line in the middle bisects the Chromaticity chart, which is analogous to the delineation of Colour Vectors as described in this essay. (from Wright, 1946, simplified)

5. The concept of Colour Vectors

Simplifying the process of teaching the concept of confusion lines (without using the Chromaticity chart) involves shifting to the more common, and more easily understood colour wheel. By plotting colours on a colour wheel, designers can easily predict the colours that are difficult to differentiate for colour-defective viewers. I call these plotted areas Colour Vectors. By superimposing vector areas on top of a colour wheel, it is easy to teach students of graphic design how to select colours that will be visible to those with defective vision.

This technique allows the designer to draw a vector around approximately one-third of the colours in the visible spectrum, and declare the entire area to be an area of greatest concern for graphic design.

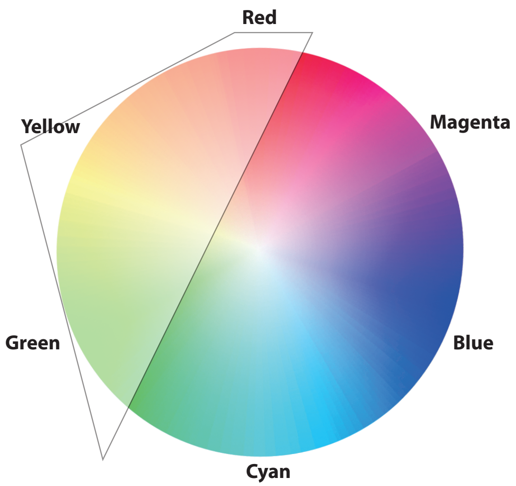

Figure 7: This Colour Vector indicates the area of greatest concern for deuteranopic viewers. Choosing any two colours from within this range is problematic because these viewers cannot discriminate between the two colours. By modifying the selection of colour pairs, it is possible to choose colours that are more easily differentiated. (Illustration by the author, 2016)

For deuteranopic viewers, these vectors converge approximately on red. The width of the other end of the vector is quite wide, encompassing all of the yellows, most of the greens, and some of the colours that exist between cyan and green at the bottom-left of the colour wheel.

Considering how few colours are present in the deuteranopic hemisphere of the colour wheel (the approximate upper-left third), the selection of a second, contrasting colour requires that the selection be made from the opposite hemisphere of the colour wheel. Colours in the cyan-blue range will usually create a difference that is easily distinguished by a colour-defective viewer.

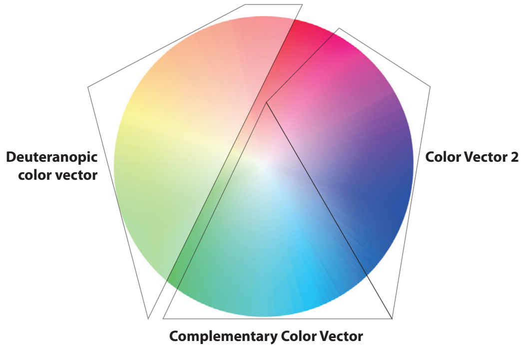

Figure 8: Colour Vectors for Considerate Colour design. By selecting one colour from the Deuteranopic colour vector (upper-left), and additional colours from Colour Vector 2 or the Complementary Colour Vector, a designer has a better chance of choosing colours that can be seen as "different" by deuteranopic viewers. A space is left between the three Vectors to enhance the differences between selected colours. (Illustration by the author, 2016)

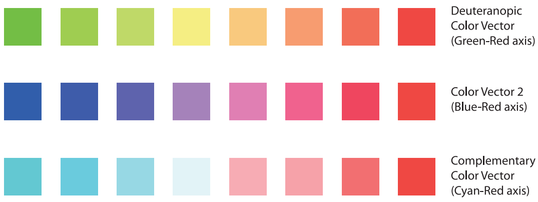

Figure 9: Three sets of eight colours chosen from these vectors on the colour wheel. The top row is chosen from the Deuteranopic Colour Vector. The middle row is selected from the Colour Vector 2. The bottom row is taken from the Complementary Colour Vector. All vectors converge on the same red colour.
(Illustration by the author, 2016)

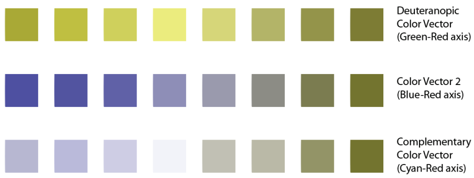

Figure 10: The same colour patches as seen by a deuteranopic viewer. As can be seen here, the selection of two colours from the first vector is problematic because the colours all appear to have the same "chroma" (colour) though there is some variation of value. The middle selection has adequate chroma differences, and two colours selected from this row would work well together. In the last row there is greater value difference (note the pale gray-blue in the fourth position), and a similar chroma difference. The middle and bottom rows would yield colours that will be seen as "different" by a colour-defective individual. (Illustration by the author, 2016)

Teachers who understand how these vectors can be applied to colour selection can assist their students in the selection of colours that are both attractive to normal viewers, and effective for people with defective colour vision.

6. The practical application of these concepts

Though using the colour wheel is an effective tool for explaining the concept of Colour Vectors to design students, it is not practical. Curiously, no popular software application presents the colour wheel as a selection tool. The Adobe Creative Cloud applications allow the user to select colours from several different palettes: HSB, RGB and CMYK in Illustrator and InDesign, with a CIELab colour picker added in Adobe Photoshop. (Hexadecimal values are a different method for describing RGB colours, not a different colour system.)
Of all these selection palettes, only the CIELab colour picker in Photoshop is useful for the selection of colours in a manner similar to that described here. Instead of choosing colours as imaginary vectors on top of a colour wheel, one can select colours from the top half or the bottom half of the colour picker that is present when the L channel is selected in the Colour Picker in Photoshop (see Figures 11 and 12).

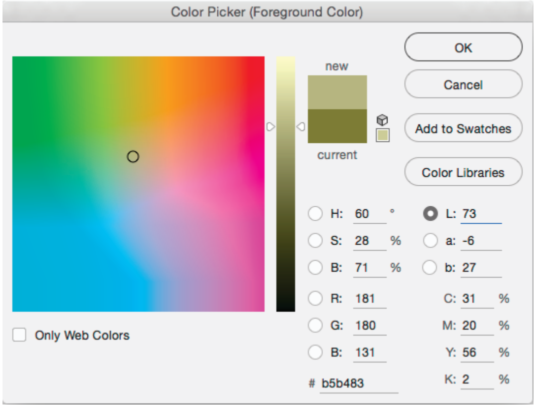

Figure 11: The Colour Picker in Adobe Photoshop presents the only location for choosing colours that are similar to using the Colour Vectors described in this essay. By choosing the L channel (shown here), the colours are presented in a way that effective colours can be selected from the upper-half and the lower-half of this palette. Such selections are essentially the same as opposing hemispheres on the colour wheel. Unfortunately, this Lab colour picker is not available in Adobe InDesign or Adobe Illustrator

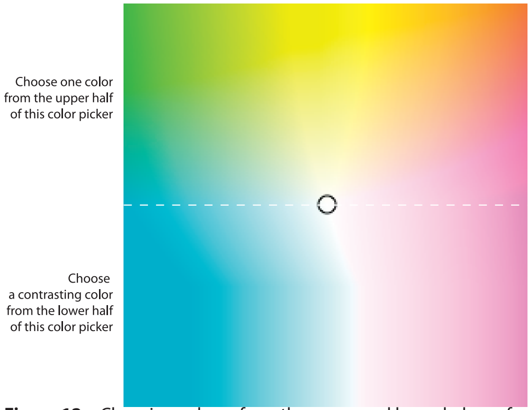

Figure 12: Choosing colours from the upper and lower halves of the CIELab colour picker in Adobe Photoshop.
(Illustration by the author, 2016)

Fortunately, there is a simple method for exporting palettes of colours that can be added to documents in the other two Adobe Creative Cloud applications. Adobe has created a menu in each application for saving swatches "for Exchange" and also for loading these swatch files (called .ase files). Once a palette of colours has been created in Photoshop, that palette can be exported as an .ase file, and then loaded into InDesign or Illustrator. Once loaded into those applications, the swatches behave just as other colour swatches do.

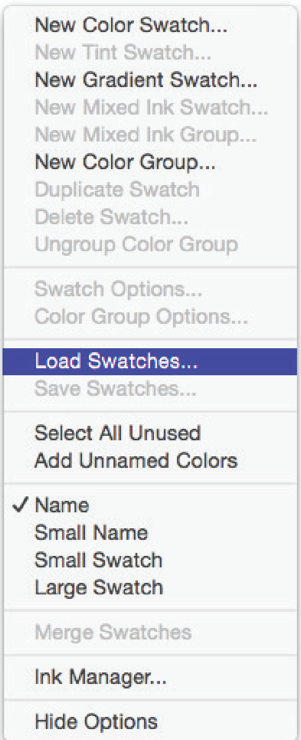

Figure 13: Loading an Adobe colour swatches file (.ase) into Adobe InDesign. By choosing this fly-out menu from the Colour Swatches menu in Adobe InDesign (or the similar menu in Illustrator), it is possible to pass colour swatches from Photoshop to the other Creative Cloud applications.

7. Simulating how colour is seen by colour-defective viewers with computer software

Graphic arts teachers can teach their students how to simulate colour-defective vision in Adobe Photoshop and Illustrator (this tool is not available in InDesign). Using either application, and choosing from the View menu, one can choose to simulate the two most common types of colour-defective vision (Adobe calls the phenomenon "Colour-blindness").

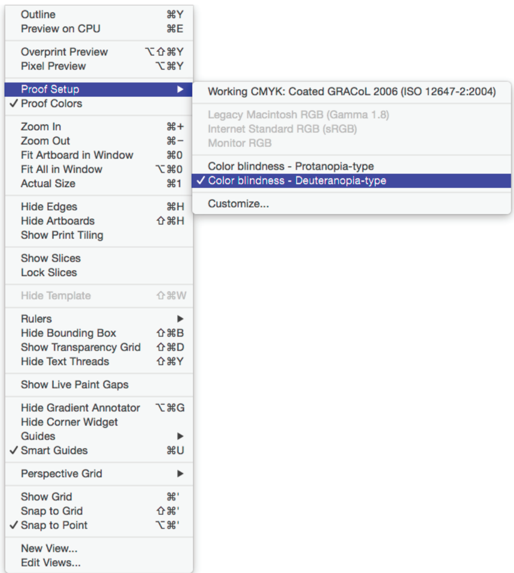

Figure 14: Adobe Illustrator's menu for simulating the two common types of colour-defective vision. The menu in Adobe Photoshop is similar

A more effective tool for simulating colour-defective vision is a free application called Colour Oracle, written by Swiss cartographer Dr. Bernhard Jenny. When activated, Colour Oracle turns the entire computer display into a simulation of colour-defective vision. It will demonstrate the three types of colour vision, and it will create a screen capture to save an example of the effect of colour-defective vision. Compared to the techniques described above (only available in Adobe Illustrator and Photoshop), this is much easier, and it works for any computer running any application.
Teachers who want their students to understand the effect of colour-defective vision can demonstrate these tools to their students, and have their students make variations of their designs to study and preview how colours interact with each other in the varied circumstances possible in Colour Oracle.

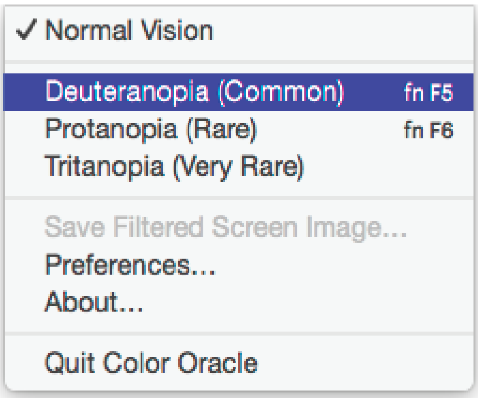

Figure 15: :The Colour Oracle menu. Selecting from the three types of colour-defective vision will turn your entire computer display into the colours as seen by a *person with that vision anomaly.*

8. Conclusion

By applying the concepts of Colour Vectors to teach Considerate Colour design, a graphic arts instructor can contribute to the education of thoughtful, skilful students. These students can then prepare artwork and colourful information graphics that are both attractive and functional. Their colour choices will help the small percentage of the population with colour-defective vision to see and understand information based on its colour as well as its content.

Note on software versions

All references to Adobe software products refer to the 2015 Creative Cloud versions, though these tools and palettes may appear in previous versions of the software.

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Business Models and Strategy finding for the Printing Industries

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Keywords: Business Models, Strategy finding, Business Processes

Abstract:

The printing industries all over the world have to find new successful strategies and business models. The reason for the necessary changes is based on the ongoing shift from analog to digital production technologies and media products, bringing about new business opportunities on the supply side in combination with changes in the media use on the demand side. The economic situation of major parts of the printing industries is a challenging task. The task for printers is to understand which technologies, processes and markets fit best to implement successful business strategies.
Therefore in this paper strategic options are analyzed based on Porters strategy model, a business model canvas, the core competence approach and the analysis of disruptive changes caused by the digitalization. In order to classify possible strategies and business models a portfolio approach with two dimensions (Technology, Market) is used. Possible business models are identified and assigned to the portfolio. Examples for business models are given.

1. Situation of the Printing Industries

The printing industries all over the world have to find new successful strategies and business models [10]. This is caused by the digital shift, new business possibilities enabled by IT and changes in media use. The economic situation of major parts of the printing industries is a challenging. The task for printers is to understand which technologies, processes and markets fit best to implement successful business strategies.

The changes in media businesses are disruptive due to the digitalization of all media processes since the 1990s. The development of the Internet led from traditional mass media to individual and interactive media, the mobile Internet to location-independent media and social networks. The latest step in the development of the Internet is the 'Internet of things and services (IoT)'. The basic idea of IoT is that most of the materials and components and all parts of productions systems will be connected to the Internet. These 'intelligent' or 'smart' things allow self-organizing supply chains and production and logistics processes.

There are major changes in the use of media. Due to mobile media and the simultaneous use of different media the overall consumption of media is expanding. Especially the generations born after the invention of the Internet, the so called 'digital natives' change from paper based media to digital media use [1]. There are different research studies coming to different conclusions whether the digital natives will change their behavior when they will turn to other phases of life.

A short overview of the situation of the printing industries is given with a focus on Germany. The reasons for the challenging situation like overcapacity and changes in media are nearly the same for all developed countries, especially Europe and USA/Canada and more and more for the emerging markets like China [19, 20]. In addition there are specific problems in some countries. For example in India problems with physical transportation of goods, and financial problems with investments in South America, e.g. Argentina.

From a technological point of view there is still a mix of printing technologies. The market share of printing press technologies depends whether the figures are based on the number of presses or the paper output in m2 or sales value. There is still a high printing volume for Sheetfed-Offset, Web-Offset, Gravure-Printing and Flexographic Printing in commercial printing (e.g. advertising, catalogs), packaging printing (e.g. folding boxes, labels) and publishing printing sector (e.g. newspapers, books, magazines, corporate publishing magazines) [2 & 3].

Gravure printing (excluding packaging) in Europe is concentrated in a few large enterprises offering high volume printing capacities. Digital printing technologies are typically used for personalized or on-demand products or large scale products with short print runs in production. Due to customer demands (decrease in circulations) and an increasing quality of digital prints the market share of digital printing is rising significantly.

Automatization and increasing printing capacity per press causes an overcapacity problem in the printing industries. In addition data for print jobs can easily be sent to low-cost parts of the world. Therefore, printers need a strong product and customer focus, strong business models and if possible integration into the processes of customers. The showroom of many German printers is still the shop floor. They present production technology instead of products. "Printers need to become more involved in their customers' businesses. Once printers can gain a deeper understanding of their customers' business strategies, they can better develop creative solutions through their services. This requires a different selling strategy for printers and encourages them to move beyond the title "printer" to a broader title that encompasses the flexibility to alter services to match their customers' needs" [11].

In Germany there are 141,000 employees left in the printing industries. The number of employees in the German print industry decreased by more than approximately 35% (i.e. more than 80,000 jobs) between 2000 and 2014. In addition the number of employees in the offset-equipment industry has decreased significantly. The number of print shops in Germany decreased from 13,900 (in 2000) to 8,700 (in 2014). Small sized companies are still typical. These figures of the German Printing Association do not include major parts of functional and packaging printing capacity. Nevertheless, a large production volume of the printing industries in Germany remains. Revenues of the German printing industry are in 2014 Euro 20.8 bn in total, and 58% of the advertising revenues in Germany 2015 are still print-based [4].

2. Research Approach

The approach adopted here uses Porter strategy view, the core competence approach of Prahalad and Hamel and the business model canvas of Osterwalder. In addition effects of the disruptive change on business models in the printing industries are analyzed. A portfolio is derived from these research aspects. Several business models of printing companies are analyzed and classified in the portfolio. In addition future business model possibilities are discussed and classified.
Examples of business models are taken from literature, especially the interviews carried out by Hongzhen Diao [cf. 7,9]. In addition the experience was used from visiting printers, printing associations, intermediates (brokers), printing suppliers and research organizations in the field of printing in Germany, Italy, India, China, Hong Kong, Singapore, Australia, USA, Canada, Argentina and Chile during the last 9 years.

3. Framework

3.1 Definition of Business Models

A business model describes how a company makes profits. It helps to understand, analyze and communicate how that is done. Parts of a business model description are:

- A description of the achieved customer value.
- Value creation architecture: How could adequate technologies and business processes

be used. In addition the understanding of the market and entrance barriers are necessary.
- Profit model: How can profits be made in the value chain?

Strategies for business improvement can be developed on basis of this understanding [cf. 8]. Mintzberg defined a strategy as a pattern in strategic decisions.

Osterwalder et al [17] describes a Business Model Canvas i.e. a business model design template. Using the template a company can easily describe its business model (Table 1). These criteria allow the comparison of Business Models in chapter 4.

Resources/ Infrastructure	**Market**
Key Activities: The most important activities in executing a company's value proposition.	Products and Services
Skills / know how	Customers segments
Finances • Classes of Business Structures: Cost-Driven or Value-Driven • Revenue Stream	Value Propositions: The collection of products and services a business offers to meet the needs of its customers. The value proposition provides value through various elements such as customization, brand/status, price, cost reduction, risk reduction, accessibility, and convenience/ usability.
Key Resources: The resources necessary to create value for the customer (intellectual, equipment, personal)	Delivery channels
	Customer relationships

Table 1: The Business Model Canvase {based on 17]

3.2 The Porter Strategy View for the Printing Industries

Using the Porter strategy view (figure 1) is helpful in understanding the situation and requirements of the printing industries:
- There are the competitors in the industry production line. Using standard technologies like Sheet Offset equipment competitors can easily imitate successful printers. Service development or own software developments (as provided by some online printers) can lead to reduced entrance barriers to markets.
- There is the threat of substitution products, e.g. digital media like E-books.
- There are new competitors. For German printers this is true e.g. for new competitors in Eastern Europe or in China for non-time-critical print products. Barriers of market access for competitors are lowered by IT (easy data transfer around the world, cheap transportation enables offshore printing). Germany imported publishing products valued 2.3 bn Euro in 2015 [21].
- There is the contracting-power of suppliers (e.g. ink, paper, equipment).
- There is the contracting power of the consumers (e.g. for highly comparable products of online-printers) and intermediates like publishers and advertising agencies.

Porter identified three basic strategies: cost leader, niche business and differentiation. These strategies and the understanding of the forces in the Porter strategy view are fundamental for the understanding of business models in chapter 4.

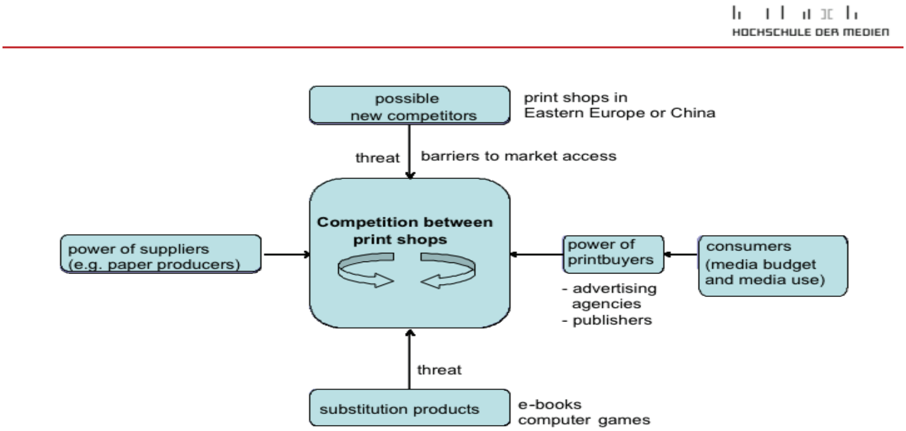

Figure 1: Porters Strategy View [cf. 5] applied on the printing industry

3.3 Core Competence Concept

A core competency is a concept in management theory. Prahalad and Hamel defined core competency as a harmonized combination of multiple resources and skills that distinguish a company in the marketplace [16]. Core competencies fulfill three criteria:

- They provide potential access to a wide variety of markets. Applying this concept in the printing industries means to use printing technology know how in non-media industries.
- They should make a significant contribution to the perceived customer benefits of the end product or service.
- They should be difficult to imitate by competitors. This should be considered, when business models for the printing industries are described in chapter 4.

The portfolio in chapter 4 focuses on companies which have their core competence in 'print' and their strategic focus on applying 'print' in different businesses and in specializing on 'print'. In addition printing technology is used by many companies which apply print as an incidental technology. In these companies printing technology is integral to in other production processes, using screen printing in the production process of a model railroad company. Another example is the printing of cells in biotechnology [15]: "We printed tens of thousands of picoliter aqueous droplets that become joined by single lipid bilayers to form a cohesive material with cooperating compartments. Three-dimensional structures can be built with heterologous droplets in software-defined arrangements. … Printed droplet networks might be interfaced with tissues, used as tissue engineering substrates, or developed as mimics of living tissue." A company using this printing technology would have no focus on 'print'. Therefore such companies are not considered in the following.

3.4 Disruptive Change caused by Digitalization

Digitalization causes disruptive change: Information about competitive offerings and new technologies is available worldwide, workflows become IT-based and allow global supply chains. Transportation costs

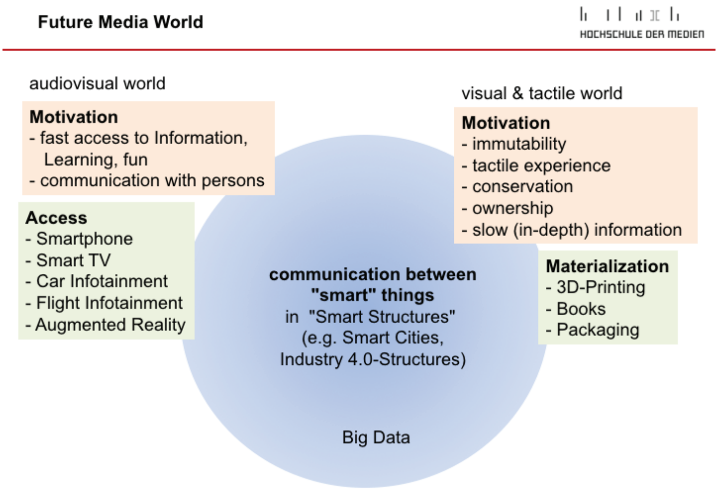

Figure 2: An idea of a futre media world

are low and allow worldwide distribution at reasonable costs. In general predictability is decreasing and uncertainty is increasing. New media cause a 'digital shift' towards the direction of digital and mobile media instead of 'print'. The motivation of media use is changing, often fast access is more important than ownership (figure 2). For the first time new media are not primarily added to existing media. There is a massive substitution effect of printed media.
In addition the Internet of things and services (IoT) is the next disruptive change for all industries including printing and packaging. The concepts of IoT are discussed as the Industry 4.0 concept in Germany, and similarly in the IIC in the US, and as 'Made in China 2025' in China.

Industry 4.0 is digitalized production including:

- M2M (machine-2-machine) communication.
- decentralized control: A high number intelligent things organize themselves (e.g. using intelligent packaging with printed RFID and antenna structures).
- personalized products: lot size 1 e.g. via 3D-printing of spare parts, prototypes or individualized products.

The German Printing and Packaging industry will be changed massively by these new developments (e.g. changes in logistics, maintenance and production control). New business models can be enabled and e.g. printed electronics can make things smart (e.g. printed antennas, RFID & batteries), and 3D-printing will be part of rapid prototyping and additive manufacturing. Business models based on these possibilities are described in chapter 4.

In general disruptive changes in businesses are caused by Innovations. These innovations allow

- new services and products by enabling new image/branding, personalization/customization of products and usage of new technologies.
- new processes: cheaper (with sometimes lower entrance barriers) or faster (e.g. web-to-print, no intermediates).
- business in new markets and with new customers (e.g. 3D-printing), using media technologies and know how outside media (printing technologies seem to vanish in other businesses from the view of some printing associations).
- new services due to changing legal and cultural frameworks and behavior (e.g. the always-in-touch and prosumer generation).
-

Christensen and Overdorf described how disruptive change has to be managed: "Before rushing into the breach, managers must understand precisely what types of change the existing organization is capable and incapable of handling" [18]. This is true for many printing companies especially in Europe. Most of them are small and medium sized. They are not capable of handling new workflows and technologies, they have no R&D departments, their financial situation is weak due to over-capacity. Many of these companies go out of business every year, the business is changing from commercial to industrial structures. One example of lack of innovation is found in the management of internationally organized value chains. German publishers often pass work to Hong Kong brokers because many German printers are not able to organize such processes for their customers.

A explicit strategy and business model will have to be found by the printers. This will be described in chapter 4. In some cases pre-competitive research can be done by establishing research organizations by medium-sized companies to share ideas and costs. The DFTA center for flexographic printing in Stuttgart is a good example for such a structure. In some cases incubators at Universities can lead to more innovative new companies.

4. A Classification for the Printing Industries Business Models

In order to classify possible strategies and business models a portfolio approach with two dimensions is used. The first dimension focuses on whether the strategy is based on existing or new technologies. The second dimension focuses on whether the market for the companies is a media or a non-media market. The four sections of this portfolio will now be explained (figure 3).

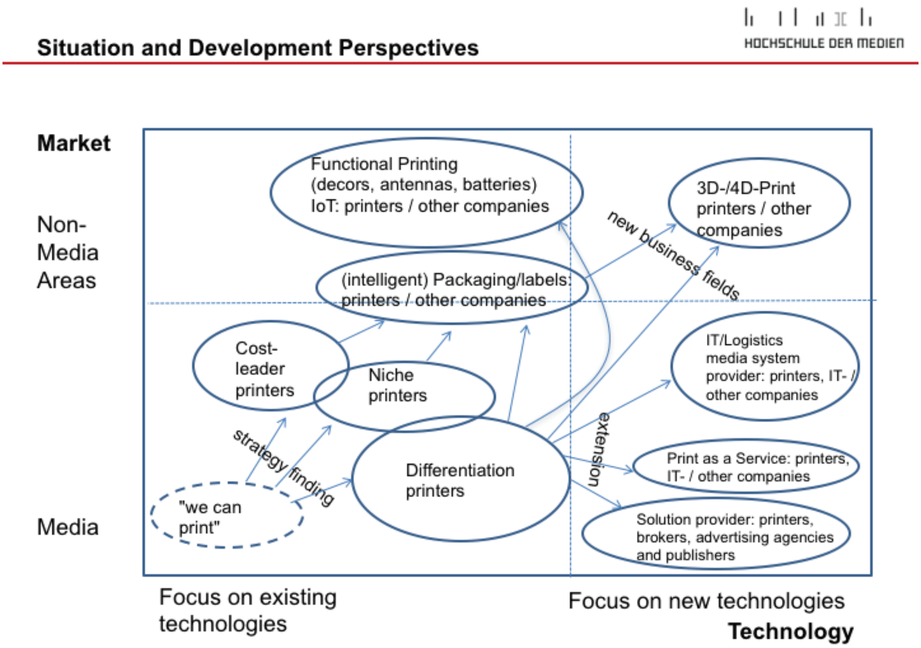

Figure 3: The printing industries situation and development perspectives

4.1 Section 1: Existing Technologies / Media Market

Many small commercial family run print shops at least in Germany still focus on their printing equipment. They have to think more about customer needs and products to be successful, not about technologies ('we can produce on a 6 color press'), i.e. they have to define a strategy and a market position. Their financial resources are weak due to comparable products, and personal resources are limited. Using the porter strategy model there are three basic strategies:

Cost leader strategy: Offer the cheapest products, e.g. via web-to-print, clearly defined products and highly efficient processes in a 'good enough' quality.

Differentiation strategy means not to offer the cheapest product but to offer a clear value to the customer, different from others.

Examples are:

- a large print shop in Singapore offering high quality and high-level world-wide service for book printing including most of the world-wide available quality management certificates.
- a regional newspaper being a cross-media platform and management platform for local events.
- a publisher which is specialized in magazines for children offering ideas and stories for well-known toy brands. Parts of a toy construction kit or doll accessories are attached at the magazines. This is an example of brand symbiosis between publisher and toy production companies.

Niche strategy printers offer a clear value to the customer which is very specific and not part of the mainstream market. Examples are:

- offering 'green' carbon-free printing including certificates.
  - a small printing company in Beijing offering a manufactory atmosphere for artists using old-fashioned collotype printing equipment.
- - a company in mainland China specializing in products for toys and children's books using lenticular printing.
- - a US-printer understanding the winery business and offering specialized printed materials including high end wine labels with customer-specific color management.
- - banknote and smartcard printers.

4.2 Section 2: Existing Technologies / Non-Media Market

A business model can be implemented by applying printing technologies in non-media industries. Examples are:

- individualized decor printing by using gravure printing.
- individualized textile printing.
- printing of antennas by using screen printing for the automotive industry.
- printing of flexible batteries.

The biggest sector for non-media use of printing technologies is the packaging printing sector (besides the aspect that packaging is important for advertising). Packaging is highly differentiated. It is used in different sectors like food, beverage, cosmetics and pharmaceuticals using different materials like paperboard, glass, metal and plastic [cf. 12]. A core competence for successful packaging printers therefore is the detailed understanding of their customer needs and processes.

In developed countries this sector is driven by increasing requirements of customers: quality requirements for pharmaceutical and perfumes product packaging, protection against forgery, culture-dependent packaging design, food-hygiene regulations, increasing number of single households (small package sizes) and age appropriate packaging. In emerging countries urbanization drives packaging printing companies: the necessity of preservation and therefore packaging of food for the citizens of mega cities especially in Asia.

Packaging cannot be replaced by digital media and is a growing sector. Nevertheless the packaging sector is affected by the upcoming of new information technologies. Changes refer to green printing & packaging (renewable raw materials, recycling, de-inking), personalized packaging, finishing possibilities in printing, smart packaging using IT RFID-tags or barcodes for improved logistics and additional information from the internet. The label business is normally done by printers. Printing directly on packaging materials like glass or beverage cans is often done in the production lines of other industries.

4.3 Section 3: New Technologies / Media Market

New business models can be implemented by 'Print as a service'. In the business-user¬¬ sector integrated print (workplace and department printers), scan and copy solutions including scan-to-mail are available. There are printing companies offering a full service package including maintenance and integration of the hardware in the customer IT. They add 'click'-based settlement systems and integration in accounting systems. The core competences of these companies are to understand the IT systems of the customers and the capability to integrate their services into these systems.

Other business models are based on a 'solution provider' concept. New services based on web-to-print, Job Definition Format (JDF) based workflows, virtual showrooms, Customer Relationship Management tools, QR-codes and database publishing can be offered by print shops. Those services are often combined with digital printing capabilities for personalization. Data usage for different media can be enabled using media-neutral database management systems (separation of content and format information) and editorial systems.

The general idea is to offer services which cover major parts of the value chain and to redefine the interface between printers and advertising agencies. Printers can use their technical skills in using print as a push media in cross-media or trans-media (telling a story across multiple platforms) campaigns.

Other 'solution providers' work on international processes. For example there are 'broker companies' in Hong Kong using innovative IT based business processes for quality management, order processing and logistics [6,7,9]. They offer the management of print jobs in mainland China for European publishers in order to provide price sensitive and non-time-critical print production. In the past German printers often did not follow this international business model. Many suppliers for example followed the German car manufacturers to China. They established production plants in China and offered their well-known services but only a few printers for operating instructions and packaging of spare parts did the same.

A new business model is the IT/logistics media system provider. For example there is a print-on-demand printer for scientific books working together with booksellers like Amazon. The printer offers digital printing for small production runs including the whole IT-oriented business process (getting order and production data from the online bookseller, handling accounting, logistics and delivery to the customer). Printers have to look for the profitable parts of the value chain. Profit margins are high, where comparability is low. This principle also applies in reverse. Offering simply 'printing capacity' means high comparability (e.g. by comparing prices in Internet portals) and low margins. If solution and service providing are offered or even better media system management than comparability is low and profit margins are high.

4.4 Section 4: New Technologies / Non-Media Market

Business Models can be defined for new printing technologies in non-media markets.

3D-printing technologies enable products for new markets. 4D-printing means that 3D-products use materials that change their volume and structure after production, which can be e.g. useful for in-ear implants [cf. 13]. In July 2014 Amazon opened a 3D-Online-Printshop in the US. Global revenues are estimated to increase from approximately 3 bn to nearly 11 bn dollars in 2021.

This field with new technologies and business processes enables a wide area for startup companies. Their business model is to support rapid prototyping and spare part production. A challenge is the quality management of end-user CAD data. Professional services for industry (architecture models, spare parts for classic cars) and end-users (e.g. jewelry parts) are offered.

Due to these technologies, the 3D-printing and the functional printing described above, the printing industries can be part of leading edge businesses, the Internet of things and services and the Industry 4.0 initiative in Germany.

According to a study of McKinsey there are only 15 newly developed technologies which will decide the future of major parts of our economy and society. Up to 25% of Germany's economic strength will massively be influenced by these technologies in 2025. The study says the potential Impact on the German GNP in 2025 will be: Rank 1 the Internet of things with 286 bn US-Dollar and rank 13 '3D-Printing' with 24 bn US-Dollar [cf. 14].

5. Conclusions

Analyzing the different business models there are several conclusions for the printing industries:

- Over capacity and changing media use requires new business models and new, innovative business fields.
- There is not a single solution for the printing industries. New successful business models are individual. They are not limited to new technologies.
- There is an increasing field of printing technology applications outside media.
- IT-Innovations are the strategic key for most of the new business models.
- Profit is often related to the control of larger parts of the value chain.
- The work force in the printing industries needs new IT-skills for designing processes, skills for global operations and management skills (management techniques like Lean Printing).
- The often negative image of the printing industries for students ('dead tree media', 'old media', 'stick with ink and sink') can change due to 3D-printing and functional printing developments. It's well known by students that even the Aston Martin in James Bond's "Skyfall" was printed in 3D.

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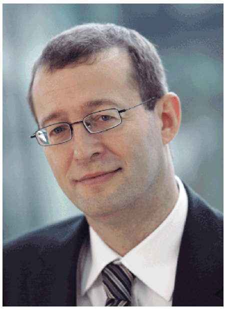

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