Factors that improve examination of student degree projects

Tommie Nystroem [1], Tobias Trofast [2]
[1]*Linkoping University, Sweden*
[2]*Linkoping University, Sweden*

tommie.nystrom@liu.se, *tobias.trofast@liu.se*

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Abstract

This report describes the process of creating a model for the development of the examination of bachelor theses at undergraduate level in the Department of Science and Technology, Linköping University, during the academic years 2010 – 2012.

The model was developed and tested at the study program Graphic Design and Communication but we also had the purpose to develop a model that could be applicable on bachelor theses in other undergraduate programs at our faculty.

The project examined whether one can improve efficiency in managing bachelor theses and the quality of these compared to previous model (see section Background). The new model is based on interdisciplinary competence groups consisting of several supervisors and examiners who, based on their core competence, jointly reviewed the quality of the bachelor thesis. Furthermore, much of the individual supervising time is replaced by group seminars for exchange of knowledge between the students who are writing their theses at the same time.

The project has also resulted in a joint assessment to create greater transparency in how different examiners assess and rate the bachelor thesis work. The project has also resulted in a template to be used for language review to enhance the linguistic quality of bachelor theses [see table 3]. The results of the new model have been evaluated through surveys among students, supervisors and examiners.

The result in the first year was to some extent disrupted by changes in regulations for thesis work at Linköping University.

Introduction

The Bologna Declaration marked a turning point in the development of European higher education. The process for building the European Higher Education Area (EHEA) also represented a very appropriate time to phase out the old paradigm of teaching in higher education, to update the teaching and learning methodologies and to focus on learning outcome [1].

The Erasmus project “Tuning Educational Structures in Europe” [2], expressed learning outcomes in terms of competences obtained by the student. Competence is a dynamic combination of cognitive and metacognitive competences, knowledge and understanding, social, intellectual and practical skills, and ethical values.

Promoting competences are subject to all educators’ fundamental aspirations. Competences are developed in all course units and assessed at different stages of a programme. Some competences are related to specific subject areas, others are more generic. It is normally the case that competence development proceeds in an integrated and cyclical manner throughout a programme. [3]

Thus, the main question posed to the student after graduation therefore will no longer be “what did you do to get your degree?” But rather “what can you do now that you've got your degree?” [4]. This approach is relevant to the labour market and is certainly more flexible when taking into account issues related to lifelong learning, non-traditional learning and other forms of non-formal educational experiences.

The international movement that wants to get away from a “teacher-centred” approach to a more student-centred learning and a “result-based” approach to education has got a greater impact through the Bologna Process. The requirement to make the teaching and learning process more transparent and more explicit presents a challenge for all involved in education [5].

The Swedish Higher Education Authority has changed the way they evaluate university programmes based on the Bologna process. They have changed from a praxis of evaluation of University education, which focused on evaluating the study programme and had a big emphasis on teaching, facilities and research body, to a new model where the focus is on the student´s competences when they graduate. This creates a strong focus on assessment procedures and highlights the importance and significance of the quality of the thesis works.

Recently ENQA (the European Association for Quality Assurance in Higher Education) noted that the quality evaluation system used in Sweden is incompatible with some of the organization's guidelines for quality assurance in higher education [6]. There has also been some criticism from representatives of higher education providers in Sweden that it is difficult to evaluate with so much focus on the thesis works [7].

Background

The three-year bachelor programme Graphic Design and Communication is a recently established programme at the Institute of Technology of Linköping University. The first admissions to the program were in the autumn 2006 and these students graduated in the spring 2009.

The programme ends with a thesis work of 16 Hp credits (corresponds to 16 ECTS), including 15 credits for the bachelor thesis and one credit for a reflection paper. Bachelor thesis work at the Graphic design and communication programme may be performed at any of three institutions; Department of Science and Technology (ITN), Department of Management and Engineering (IEI), or Department of Computer Science (IDA). Thesis work may be performed either externally on behalf of a company, organization or the like or internally at any of the above institutions, possibly in collaboration with a research group.

This project report covers only thesis work done at the Department of Science and Technology. Until and including the year 2013, ITN examined annually about 20-25 thesis work within the area Graphic Design and Communication. These works have been divided between 4-6 examiners and supervisors. Up to and including the year 2010 the same person normally was both supervisor and examiner. After a change of examination rules at faculty level 2011, one person cannot be both supervisor and examiner.

Within our department, 30 teaching hours are allocated for single student supervising and 36 hours for supervising a pair of students. Examiners have 8 hours allocated for a single student, and 10 hours for two students who write together. We always encourage our students to write in pairs but it is perfectly allowed to write individually.

During the years 2011 to 2014, The Swedish Higher Education Authority will evaluate all Swedish University and University College courses. The emphasis of the evaluation will be on the quality of the theses.

From “The Swedish Higher Education Authority's system of quality assessment 2011-2014”:

> “*The students' independent work, together with the education results reported in the self-evaluation will be the main basis for the overall review.”*
> “*The most extensive support to the evaluation will be the independent projects (degree projects) as part of the course requirements for almost all degrees. The assessment of the independent projects based on the objectives of the exam description of the program. The evaluations will consist of at least 5 and a maximum of 24 randomly selected theses per programme. The group of assessors will then submit a proposal for a* ***gathered Review*** *for each course on a three-point scale. The proposal should clearly demonstrate how well students are considered to have achieved the objectives the education are evaluated against.”*

Aims and objectives

With the above as background, the authors of this report applied for faculty funds for educational development with the purpose to develop and evaluate a model for the examination of bachelor theses. The project has studied if there are ways to increase pass rate, efficiency and quality compared to existing models.

By working in interdisciplinary competence groups (see section Method and Implementation), we hoped to increase the quality of bachelor theses in terms of content, structure and language. The project also aimed to identify whether more group supervising can lead to increased pass rate, that more theses are completed in due

time. In the project we also hoped to find appropriate parameters for common criteria in assessing and grading the students' work.

Method and implementation

Method

Two basic methods were chosen for supervising in the project;

1. Group supervising in seminars where examiners were divided into two interdisciplinary competence groups, (hereafter called the team)
2. Traditional individual supervising, supplemented by special proofreading

Work team composition and duties

The two teams had similar mixture of competences

- One person responsible for graphic production / media production
- One person responsible for visual communication
- One person responsible for graphic design.

In addition to the responsibilities mentioned above, the aim was also that each team should have a mixture of experiences - both individuals with focus on theory and research and individuals with profound experience from the graphic and creative industries. Each team was responsible for 10-12 thesis projects.

Students with similar or closely related subjects in their thesis proposal were placed in the same team and given suitable supervisors and examiners. Even if the roles and responsibilities of the supervisor and examiner are different, all steps and decisions in the process were discussed within the team. All thesis were assessed at one or more stages by all examiners and supervisors in the team. This way, a consensus on criteria was created.

Group supervising

The group supervising seminars had two main purposes: to make supervising more efficient and to create opportunities for the students in the team to share experiences, resources and knowledge. The seminars also served as clear milestones to ensure that thesis work made progress as expected. The hope was that this would increase the pass rate of finished theses, partly because this model would detect in an early stage if some of the students did not keep the pace.

All seminars had a similar setup. The students were divided into four groups, based on the topic and the choice of method in their thesis. The number of occasions and the length of the seminars depend somewhat on the number of students and the distribution of topics. In some seminars each student or pair of students act as opponents to a thesis work. After that, the seminar turns into a group discussion and finally there are comments from the participating teachers. In this way, students can have joint critique and they can also see their thesis in comparison to others, which may develop or confirm their view of their own approach.

Seminar I – Idea

In preparation for the first seminar, the students handed in a research idea with a brief description consisting of

- Idea
- Title
- Planned work schedule

Each thesis (single or pair work) gets 20 minutes with each team and with no other students present. The aim is to provide quick and immediate feedback on the idea, if it is clear, viable and has a sufficient academic level.

Seminar II – Planning Report

After working with their ideas from Seminar I, now for the first time the team and the entire student group meet. The second year we divided the students into two smaller groups per team. This was done as a result of the survey we did after the first year, where smaller groups were one of the things the students wished.
The students gave oral presentations, lasting about 10 to 15 minutes:

- Problem / Issue
- Purpose
- Method
- First preliminary selection of literature

After the presentation followed ten minutes of commenting from examiners and the students. After the two first completed seminars with good preparation and feedback from both students and team of teachers, the students are hopefully having a solid foundation for the following phases in their projects. At this step, the students shall write a planning report to be approved by the examiner before the students are allowed to start their thesis work.

Seminar III – Mid-course seminar

According to LiTH regulations regarding thesis work, a review of the thesis has to be made halfway into the work (in this case after about 5 weeks).

This is what the regulations says:
"*Half time control shall be conducted at such time as is specified in the planning report, and it is your responsibility as a student to call attention when it's time. Normally this happens about halfway into the thesis. You should then to the examiner report how work is progressing relatively the planning report. Also the supervisor should then participate. The forms of half time control can range from a verbal briefing to an open seminar and is determined by the examiner".*

Halftime review can lead to three possible outcomes:
1. The work has been substantially completed in accordance with the planning report and can continue as planned. **Intermediate report is approved.**
2. Work has been carried out with some deviations from the planning report, the work is considered to be completed with minor adjustments in problem formulation, approaches and / or schedule.
Intermediate report is approved.
3. Work has substantially deviated from the planning report and the work is likely to be rejected **Intermediate report control is not approved. A new planning report must be generated and a new half time review made**.

Half-time control was conducted in connection with the third seminar in which students in front of the team and the entire student group presented as follows:

- Title, purpose, question, methodology
- Work performed, current status, proposed continuation
- Problems

At this seminar, for the first time, opponents were appointed to the presentations. The opposition was both written and oral and the opponents, who were appointed by the team, got the respondents half time report in good time before the seminar so there would be time to prepare the opposition. A predefined opponent template (see Table 1.) was used so the students could practice their critical reviewing for the coming final presentations of thesis work.

Table 1: Opponent template

Review Items for Students	**Questions and comments**
1. Is there a proper scientific basis? (How are the terms used?)	
2. Is the main question possible to answer? (Is it to wide?)	
3. Is the chosen methodology appropriate to answer the question?	
4. The usage of Empirics? Is the empirical data good enough to answer the question or should more be obtained? Does the question have to be adjusted?	
5. Analytical method! How will the material be analysed? Would it be possible to use another method?	
6. Is it relevant to the main field of studies?	
7. Identify problems or risks to the completion of this thesis?	

Seminar IV – Rehearsal

Approximately two weeks before the scheduled final presentation a rehearsal seminar was held where students were expected to act the same way as in at the final presentation.

The format for the seminar resembled largely the one used in Seminar III with the difference that the thesis is now expected to be 90-95% complete and the oral presentations focused more on:

- Analysis
- Results
- Discussion

Prior to the seminar, the team gathered to jointly decide which theses were advanced enough to be approved for the final presentation.

Assessment Model

As mentioned previously, a common assessment model was developed and was used through the process with follow-up both at seminars and individual supervision.

Table 2. Assessment template

Occasion:	**Name:**			
Title of thesis:				
Assessment	**To correct**	**OK**	**Comment**	**Action**
Purpose / Issues				
Problematization *(why the subject is interesting for the field of studies)*				
The aim is reasonable and delimited				
The research questions are possible to answer				
Independence / Relevance *(research, clients, programs*)				
Method				
Description and motivation of the chosen method				
Transparency, is the survey repeatable				
Applicability *(collection of empirical data and how it is analysed)*				
Method Discussion *(discussing advantages and disadvantages of the method)*				
Literature				
Terminology *(concepts described)*				
Application and use of concepts				
Critical approach				
Previous research described				
Results / Analysis				
Theory and empirical evidence are brought together				
The result is conveyed				
Interpretations				
Scientific relevance, new knowledge is generated				
Discussion				
Synthesis				
Critical approach				
Feedback to problematization?				
Transparency of the work				
Communication skills / language				
Objectivity and clarity				
Readability				
Structure, context				
Formal requirements				

Individual supervising

During the entire period, students were given the opportunity to get individual supervising by their supervisor. This offer was used by all students, but to a varying extent. (See section Results)

Proofreading

In order to enhance the linguistic quality of degree works and in this way among other things facilitate the work of examiners and supervisors, two language lecturers participated in the project. Their work was based on a model for language review that was developed for the project (see Table 3). The model clarifies responsibilities, and fosters collaboration between language supervisor and student.
Language supervisors and students met when the students had produced about 10 pages of text that could be discussed. The text should include the purpose, research questions, methods, and some kind of background section. Before the meeting, students would self-review their text based on some fundamental questions about the language and layout (see Table 3). The text was then sent in advance to the language supervisors via email so the supervisor had time to review the text before the meeting.

Table 3: Template for language review

Checklist for students *(to do before the meeting)*	**Questions and comments**
Is the title clear enough?	
Is the formatting clear (e.g., levels of headings, paragraphing, appendices and references)	
Are the used typefaces appropriate?	
Is the location and design of tables and figures appropriate?	
Are there captions to figures and tables, and are these numbered and designed properly?	
Is pagination present and is it suitably located?	
Is colloquial language used?	
Is consistent terminology used?	
Reviewing Items for language supervisors *(to do before and during the meeting)*	**Questions and comments**
Is the language understandable, relevant and specific enough? (Scientifically)	
Is the reasoning obvious?	
Is there a common thread/logical disposition?	
Is the aim and questions distinct and possible to answer?	
Are the references correct in the text and in the reference list?	

Presentations in large group

As a logical consequence of the seminars with team groups, the student groups remained intact at the final presentations. In this way, the theses in the same team and with similar subjects were to be presented on the same day. If possible, the same opponents as in previous seminars made the opposition. The presentation in a large group with all the students present contributed to a larger audience, which is considered to be positive.

Results

Different types of questionnaires have been used to evaluate if the project did meet the objectives outlined. One questionnaire was sent to participating students and one questionnaire was sent to participating examiners, supervisors and language supervisors. The project ran for two years. Based on results from the first year, we decided to create a clearer connection to the course in scientific methodology given to the students just before the thesis work starts. This was particularly important for the choice of research methods. We also reduced the sizes of the seminar group and we put even more effort into creating groups with similar subjects in the same team.

Pass rate

To measure pass rate, we compared the amount and dates of theses submitted during 2010, 2011 and 2012. The model that this report describes was not used the year 2010. Year 2011 was the first year the model was tested. For the year 2012 we had further refined the model. Students who follow the seminar series should normally submit their thesis in June the same year the thesis was started (after about 10 weeks of full time work). A second opportunity is normally given for presentations in August the same year. The examiner and the student can agree even on later submittance.

The table below shows the percentage distribution of the presentations for the relevant years.

Table 4: Submitting of dissertations 2010, 2011 and 2012

Year	Dissertation in June	Dissertation in August	Dissertation later	No Dissertation
2010	64%	20%	16%	3
2011	65%	23%	12%	4
2012	89%	11%	0%	2

Efficiency

By efficiency we in this report mean the amount of time spent on supervision and examination of the thesis. To measure this, the supervisors, proofreaders and examiners were asked to note the time consumed at seminars, individual supervision, reading reports and more. On average the following amount of time were used on one thesis:

Seminars:	9.5 hrs.
Individual supervision:	2.3 hrs.
Proofreading:	2.5 hrs.
Examination (including final presentation):	4.1 hrs.

On average, 18.4 teaching hours were spent on each thesis during the tested period. This shall be compared to the amount of teacher time that is allocated by the department for thesis work:

Supervision: 30 hours for a bachelors thesis if a student writes an individual work and 36 hours if there are two students who write together
Examination: 8 hours for a single student, and 10 hours if there are two students who write together.

Quality

We have chosen to let the involved examiners evaluate the quality of bachelor thesis achieved by 2011 – 2012 compared to previous years (2009 – 2010) using a questionnaire. By summarizing the survey responses, we can present the following results: All of the respondents feel that the quality is higher but above all, the general level is more even compared to previous years. Many also point out the examiners' joint assessment as a contributing factor to enhance the quality of the theses.

Conclusions and discussion

Conclusions

The objective of the project was to develop a model that improves the quality, efficiency and pass rate for theses work at Bachelor level. Based upon the results presented in the previous chapter, it can be said that the model we developed easily meets these objectives.
It is clear that the efficiency has increased when students with fewer hours of supervising than before, still have carried out their thesis work with good quality and within the stipulated timeframe.
Pass rate has also increased compared to the years before the model was applied, largely because of the continuous feedback that occur in connection with the joint seminars. Pass rate is also affected by the fact that the students at these joint seminars can support and inspire each other.
Since the students are better prepared in scientific methodology from the course given just before the thesis work begins, they can formulate objectives and decide on methods earlier in the process.

We have not had a good instrument to measure the quality of the theses. We have asked the teachers about their perception of the overall quality compared with earlier years. The common perception is that the quality is more consistent than before, the reason for this we believe to be two things. First, the joint seminars where students can compare their work with similar work on several occasions. These seminars also created a shared assessment basis for the examiners. Second, the element of language checking made about halfway into thesis work increased the linguistic quality of the works. It has also made it possible for the examiners to fully focus on the content of the thesis in assessing and not on language quality.

Discussion

It should be emphasized that the joint seminars alone are not enough supervising. Individual supervising must complete reconciliation of the thesis work progresses between seminars. This individual supervising tend to take more time for thesis projects carried out individually compared to those performed in pairs. The current model does not account for that.

One recommendation is to try to keep seminar groups relatively small. About 4 theses per group who write about a similar topic or use a similar method. For larger groups, we noticed that the discussions and engagement decreases and seminars tend to be a burden rather than an asset to the students.
We have only tested this method on the bachelor program Graphic Design and Communication and therefore cannot assure whether the model works for other candidate programmes, but are confident the model should work for others, possibly with minor adjustments.

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Author biography

Tommie Nyström is present working as lecturer in Graphic Communication at Linköping University, teaching within the field of Graphic Communication and Design, including Information Design, Typography and Visual Communication Projects Management at two study programmes: Bachelor in Graphic Design & Communication and Master of Science in Media Technology and Engineering.

He is also the Vice Chair of the Study Board for Computer and Media Technology and Chair of the Operational board for the study programme Graphic Design & Communication.

The winter semesters 2010-2011 and 2012-2013 he was guest lecturing at Stuttgart Media University (HdM) teaching typography at the study programme in Information Design.

The year 2009 he held a full time position as Guest lecturer at HdM teaching typography, type design and graphic design. His working language was English.

Uncovering the Qualities of a Successful Internship: A Longitudinal Evaluation of Internship-Based Experiential Education in the Graphic Arts

Natalia Lumby[1], Diana Brown[2]

[1]*Ryerson University, Canada*
[2]*Ryerson University, Canada*
nlumby@ryerson.ca, d7brown@ryerson.ca

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Abstract

This study presents an analysis of feedback data gathered evaluating the performance of students in their internship over the period of five years (2008-2012). The descriptive analysis synthesizes 414 employer evaluations in the form of a survey. The research is exploratory, attempting to identify what common themes emerge from both structured questions and open-ended comment responses, with statistical analysis as well as content analysis applied. Word clouds are used as a research tool to establish key internship characteristics that emerge most commonly in the feedback provided. Here we find that there is a strong emphasis on soft skills, with no significant changes over time. Employers identify that the ability and willingness of an intern to work hard and learn quickly are very important. Further, employers most often praise individuals on professionalism and their ability to work as part of a team. The importance of specific domain knowledge is also addressed; with the interns rated slightly better for their technical skills, than for their business skills. The emphasis on soft skills, which could typically be identified more broadly as business skills, along with the slightly weaker ranking, lead us to believe that students would benefit from more coaching in this area. The benefits of soft skills are then further supported in the literature. Thus along with the identification of key traits for a successful internship, we finish off the study with some curricular recommendations.

Introduction

In today's competitive job market, students who are able to translate theoretical knowledge into practical workplace skills have greater opportunities for career advancement upon graduation. The framework of an internship provides an excellent opportunity for students to experience working in their industry first hand, under the guidance of a mentor in their field. Internships are characterized as a type of "experiential learning" opportunity (Cantor, n.d.). Experiential learning through an internship program benefits students in various ways, including developing professional and personal skills, as well as connecting to the greater professional and civic community (King & Sweitzer, 2008). Herein lies the essence of experiential learning: "I hear and I forget. I see and I remember. I do and I understand." (Gentry, 1990, p.9)

For young professional in the 21st century, it is not enough to only possess technical or "hard" skills; employers also want candidates to possess interpersonal or "soft" skills (Junor & Hampson, 2009). Hard skills are defined as "those skills acquired through training and education or learned on the job and are specific to each work setting", whereas soft skills are defined as "the cluster of personality traits, social graces, language skills, friendliness, and optimism that mark each one of us to varying degrees" (Arnett et al, 2004, p.1). Although many employers advertise the need for technical skills in job postings, various, unadvertised soft skills are integral to the final hiring decision criteria (Arnett et al, 2004). A joint study by a Stanford Research institute and Carnegie Melon Foundation found that a remarkable 75 percent of long-term job success could be attributed to soft skills versus only 25 percent that could be attributed to hard skills (Arnett et al, 2004). Studies like this make a case for teaching and developing a greater number of soft skills as part of a larger graphic communications curriculum.

Possessing "employability" or "transferrable" skills that translate across job titles and disciplines are especially relevant to management positions. It is evident that employers are looking for critical soft skills, which can be harnessed during periods of study or work experience (Raybould & Sheedy, 2005). The Canadian Printing Industries Sector Council (CPISC) recommends that employers "hire people with the capabilities to learn new skills, adapt to new work processes and take on different roles" (CPSIC, 2009a). Internships in the printing industry not only provide valuable technical skills training, but they also provide an opportunity for students to acquire and develop vital soft skills.

Additionally, the terms "hard" and "soft" skills can be tied to concepts of intelligence quotient (IQ) and emotional quotient (EQ), also called emotional intelligence (EI). EI can be described as "the intelligent use of one's own and others' emotions", which relates to the concept of "soft" skills (Barone et al, 2000, p.332). In a head-to-head battle of candidates with equal levels traditional intelligence, the way to stand out from the competition in today's team-based environments is demonstrating EI (Farnham, 1996). Where educational institutions have typically focused on developing IQ, EI is a transferrable skill that should share the focus to some degree. It has been identified that maximizing the opportunity to practice soft skills (in an internship, for example), paired with faculty support to help establish and maintain these skills, is critical in training tomorrow's leaders (Barone et al, 2000). This is an important shift in institutional thinking that paves the way for modifying curriculum and incorporating experiential learning models.

The benefits of experiential learning in the printing industry remain consistent on a global scale, whereby graphic communications institutions in China see benefits in a "combination of study and work" as the main focus of professional printing training (He et al, 2011, p.638). Specifically, there is an opportunity for integration of soft skill development in management studies, as these courses have been shown to build students' emotional intelligence (Callister et al, 2003). In a service-based economy, organizations are using more than just products to compete in business; they are leveraging their human resources, which makes fostering emotional intelligence in both classes and through experiential learning capacities very relevant (Callister et al, 2003).

The Canadian Printing Industries Sector Council (CPISC) identified that 49 percent of printing companies in Canada view the issue of retirement as either extremely important (13%) or somewhat significant (36%). Additionally, 53 percent of firms that see retirement as an extremely important issue in their business, say they plan to increase new employee recruiting efforts (CPISC, 2008). Furthermore, in this CPISC study, participants were asked to make comments about the overall nature of their human resources challenges, and an important recurring insight arose regarding the lack of education and training programs for the printing industries (CPISC, 2008). Drawing from a pool of qualified candidates in highly specialized roles can be difficult and 90 percent of training in the Canadian printing industry is conducted employee-to-employee (CPISC, 2009b). This statistic reinforces the concept of "hiring for attitude, training for skill", perhaps because there is not a large enough candidate pool with the adequate specialized skills (Taylor, 2011). The aging demographic of the Canadian printing industry, paired with the demand for specialized knowledge provides an excellent opportunity for graphic arts training schools to work to fill those spaces with appropriately skilled candidates. There is a unique opportunity for higher education institutions to improve their partnership with industry, as well as the employability of their students through experiential learning methodologies when combined with traditional classroom learning (Kolb & Kolb, 2005).

This study evaluates what skills and attributes are important to employers in the printing industry, including both hard skills and soft skills. The study reveals that there is an opportunity to improve the way graphic communications management schools understand the success factors of internships, thus modifying the curriculum and overall student preparation to produce the best possible pool of candidates.

Research Methods

This study uses data gathered from a survey completed by employers at the end of an internship term in a graphic arts school located in Toronto, Canada. It is a descriptive study, analyzing five years of longitudinal data from 2008-2012. While a variety of studies have identified traits necessary for successful internship completion or employment, this was an exploratory study for the school. Namely, the initial intention was to identify what traits are important to employers within our school thus informing ways to improve candidate readiness and curriculum.

While the original surveys had a broader variety of questions, only three fields were selected for analysis. This is partially because the data was in hardcopy, making its digitization time-consuming, and partially because the other questions did not inform the initial research question.

The study had both quantitative and qualitative components. Firstly, we interpreted results for ratings given for business and technical skills. This portion of the analysis was strictly quantitative with the results indicated in percentage frequencies of each category. We selected these questions on the basis of the literature review, which identified both these skill sets as critical to successful employment (CPISC, 2008).

In addition we analyzed the freeform written comments made by the employers. This was done through a content analysis, with important concepts being coded and then mapped using a word cloud. A word cloud (or wordle) is a tool that allows you to visually see the most commonly occurring words in a body of text by making them larger within a grouping. It allows the researcher to identify key topics and themes efficiently (McNaught *et al*.,

2010). Thus, in both the quantitative and qualitative responses analyzed we explored the frequency of response type.

The wordle tool was appropriate for this study because it is a simple way to represent large amounts of quantitative data visually. Further, the exploratory nature of this study meant that key terms emerged from the analysis. At this point, no causal or correlational results are established, rather descriptive key terms have emerged from the analysis. These will be discussed in the following results section. Lastly, because the purpose of the study is to be able to inform the concepts taught within the curriculum, being able to identify the skills valued by employers allows for integration of their development.

Results

The longitudinal results of this study area analyzed year-by-year for each of the five years, as well as being combined into one data set that is not timeline specific. A total of 414 evaluations were gathered over the 5 year period (2008-2012) While the employer evaluation surveys asked a variety of questions, the focus of this analysis was to determine what qualities employers isolated as important in their comments about the interns. In addition, each intern was given a general rating for his or her business and technical skills. The results of these ratings are also analyzed here, with the comments often supplementing the thought processes of the employers as they completed the ratings.

The year-over-year results of the employer comments reveal that there is a strong emphasis on soft-skills during internship. Moreover, the skills important to employers did not change dramatically from year to year, indicating a likelihood of a core set of traits employers tend to seek. Table 1 indicates the top three most commonly occurring traits by year. It is important to note that they are not listed in order of significance, as each of the top three was rated approximately equally. We can see that working well within a team is highly desirable, along with a strong work ethic, demonstrated by the ability or willingness to work-hard. In addition to these traits professionalism and the ability to learn quickly are also recurring.

Table 1: Most popular traits in employee comments

Year	Traits
2008 (n: 85)	Quick learner Technical Team player
2009 (n: 65)	Team player Willing Quick learner
2010 (n: 86)	Professional Hard working Team player
2011 (n: 80)	Hard working Team player Independent
2012 (n: 98)	Willing Professional Positive

The comments were then analyzed without being separated by year. Figure 1 is a word cloud that displays the most commonly occurring traits across all five years. In this visualization the larger the word, the more frequently occurring it is with colour having no statistical significance. Here we can see many similarities as the yearly results previously discussed. Again, working hard, as part of a team appear as key positive traits. In addition to these soft skills we see some hard skills appearing. Technical abilities, which include the ability to use software, technology and graphic arts related knowledge, are highly relevant. However, the emphasis is predominantly placed on the soft skills of the intern. By visualizing these traits we can begin to compartmentalize them, and reinforce them within the curriculum.

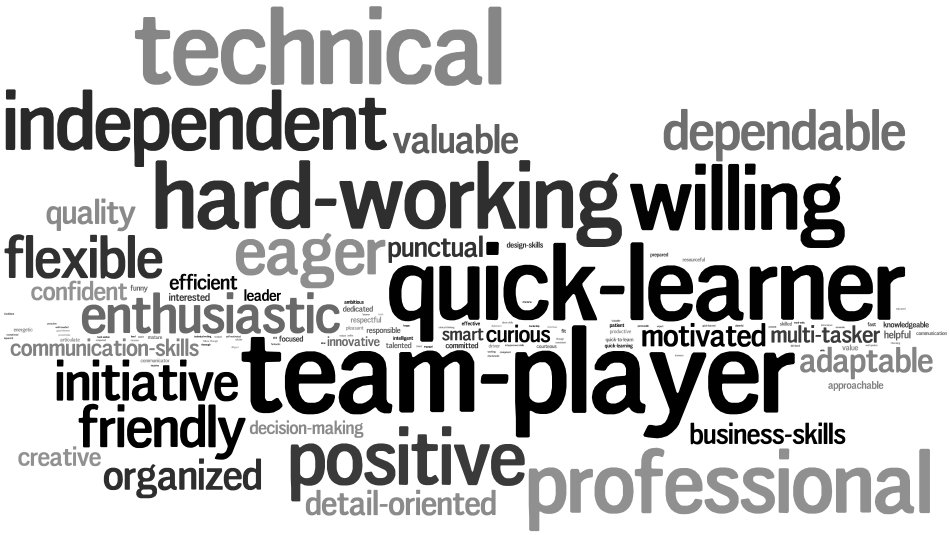

Figure 1: Positive traits of interns from 2008-2012

In addition to the positive comments listed by the employers we also analyzed what traits employers thought some interns were lacking. A year-over-year analysis of negative qualities was not completed, as too few such comments existed in each individual year. Rather a combined 5-year visualization is displayed in Figure 2. We should note that due to the small number of these comments, they might not be as representative. It is interesting to note that they mirror the positive comments in some ways. For example, when employers identify a lack of initiative as an issue, they are hoping for better work ethic from the employee. A unique comment worth noting is the student's level of confidence. In many cases where the intern was not evaluated highly, the employer identified them as needing to be more confident. Building confidence is an important part of learning, as will be addressed in the discussion.

Figure 2: Negative traits in interns from 2008-2012

Lastly, the study looks at the intern's technical and business skills overall, in each of the five years. In Figure 3 we can see that about 50% of the time the students have average or better technical and business skills, with very few reported instances of a lack of knowledge in a particular area. The figure also illustrates that the students generally display stronger technical skills than business skills.

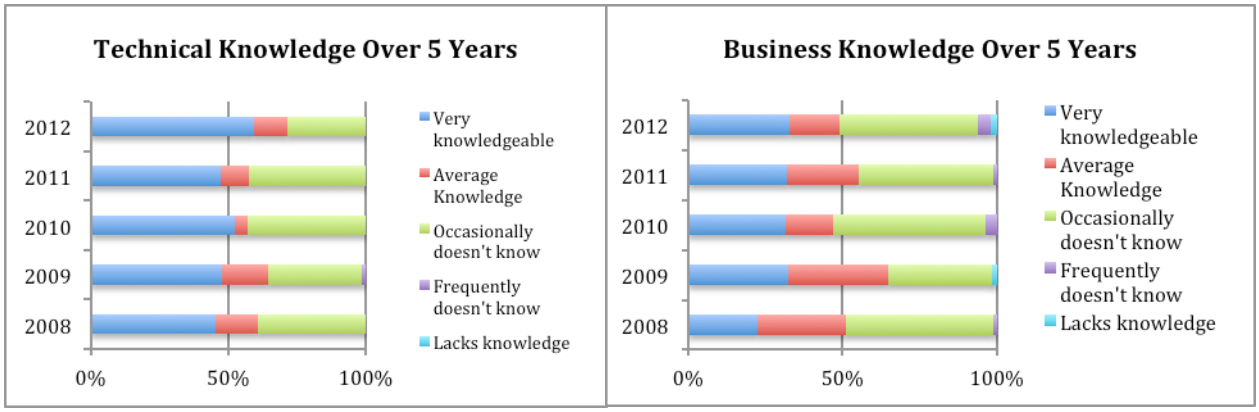

Figure 3: Rating of Technical and Business Knowledge (2008-2012)

Discussion

The results demonstrate several interesting implications for understanding what composition of skills and attributes make a successful intern. Certainly there seems to be an emphasis on the soft skills of candidates, reinforcing that emotional intelligence is an important tool the students should attain. Secondly, it is interesting to see that the top rated traits did not seem to change significantly across the five years of this study. Both of these notions are supported by the literature. While the data was gathered and analysed in an exploratory manner, the themes that emerged are in-line with other research in the area.

Forbes reports on a global research study conducted by Universum, a European employer branding firm, which showed similar key traits as being desirable. Professionalism, high energy and confidence were reported as the top three traits followed closely by self-monitoring and intellectual curiosity (Casserly, 2012). It can be seen that the positive attitude, willingness to work hard and professionalism represented in the results of this study closely resemble the top five of a much broader sample. Interestingly however, employers did not specifically point to teamwork skills as being important. Seemingly, teamwork is a very important skill in the graphic arts industry. This could result from a heavy emphasis of workflow stretching across many departments in the graphic arts industry.

Academic studies also support the importance of soft skills. For example in a study identifying the importance of hiring criteria, communication skills, problem solving, analytical skills, computer applications, leadership and teamwork were all important (Kelley *et al.,* 1990). Even as far back as 1988, Boatwrite and Stamps found that what they called "self-starter" skills, like ambition and motivation, along with communication and leadership skills were keys to success. When measured across both academic and corporate respondents, cognitive, social and personal skills were most important, though experience and knowledge of the field are still necessary (Bikson *et al.*, 1994). Generally we see that specific domain knowledge is ranked less important than a variety of soft skills (Bansak *et al.*, 2005).

We know that soft skills and emotional intelligence are transferable across a variety of job types and even industries. However, while some general attributes of a successful intern may cross these boundaries, there are also attributes that tend to be industry specific. In a startup environment the emphasis is on skills that relate to a self-starting attitude such as passion, entrepreneurial spirit, motivation, versatility and the ability to work well under pressure (Rayford, 2013). Thus, the inclusion of teamwork as an important trait is another example where particular attributes are desirable within a given industry. More generally, it was found that in mass communication and technology skills have a positive impact on job-finding success (Lowrey et al., 2001).

In addition to establishing the positive attribute sentiments made by the employers it is equally important that negative attributes identified in the study are well understood. While few negative comments existed for analysis, it can be seen that the word cloud identifies a lack of intern engagement. The lack of dependability along with the inability to be punctual, are some examples of this. There are also some hard-skills identified such design skills. This would indicate that an employer is dissatisfied as a result of working with an intern who is underprepared academically. Most importantly however, issues of confidence and decision-making are identified. Confidence is often connected to one's belief in his or her abilities. As such, this too could indicate an underprepared intern.

The benefits of internship are many, with graduates who complete an internship demonstrating higher GPAs, an easier time securing a job and even higher wages (Bansak *et al.*, 2005). Given these successes, it is beneficial to measure the outcomes of internship. Soft skills are often critical to job success, however they are also difficult to

measure and subjective. The survey results analysed in this study are one way in which the school assess internship success. Interestingly it is also one of the limitations of the study. After completing the study we feel that more specific competencies could have been explored. For example, employers were asked to rate the intern's business knowledge. This is quite broad and can serve better if broken down more specifically. How it is broken down can be informed both by the data found in this study as well as that found in literature. For example we know that the ability to work as part of a team is critical, as are communications skills (both written and verbal). As such these would provide better indicators for internship success. Of course one also has to be cautious of the number of questions asked, as to prevent incomplete surveys due to dropout. Furthermore, employers should be prompted to indicate any skill deficiencies, thus providing more complete and holistic results even in very positive internship evaluations.

Another suggestion for improving internship assessment would be to create learning outcomes or categories similar to those discovered in the literature where broad areas such as cognitive, social and personal skills are rated alongside domain knowledge (Bansak *et al.*, 2005, Bikson *et al.*, 1994, Kelley *et al.,* 1994). Employers can be given descriptors of each category to ensure that the rankings are less subjective. These should also be discussed with the students throughout the year in preparation for internship, allowing them opportunities to build the skills prior to beginning their internship. Assessment methods that we feel support the development of soft skills include team projects, presentations and case studies to name a few. Having students participate in short-term industry related projects would also be highly beneficial. This can be accomplished through weeklong job shadowing assignments or small projects on-sight at a company.

Conclusion

From the results of this study in can be seen that a balance between teaching hard and soft skills is necessary. In particular we identify that soft skills are attractive to employers and can be better developed within the management-focused courses existing in the curriculum. Such development may look at a variety of teaching methods such as team projects, case studies, presentations, job shadowing and short-term industry projects.

In addition to providing students with opportunities to strengthen the critical skills identified, it is important to continue to engage with industry in order to iteratively respond to changing demands in skills needed. Here, both qualitative and quantitative research methods were used to derive the current employer needs. This has allowed us to establish that the method of capturing feedback and information is also important. Thus we suggest that soliciting information about both current and future desired needs can be accomplished using both open and more structured communication approaches.

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Author biography

Natalia Lumby is an Assistant Professor at the School of Graphic Communications Management at Ryerson University in Toronto, Canada. She teaches in areas of layout, premedia and management, focusing on delivering experiential learning opportunities to students. Her research interests concentrate on the link between print and digital media. The goal of her research is to interrogate the possibility of infusing traditional print with the advantages of digital technology. More specifically she is currently focusing on extending these concepts into print packaging.

Diana is an Instructor in the School of Graphic Communications Management at Ryerson University she has been teaching Continuing Education courses since 2009. Diana also acts as the School of Graphic Communications Management's Internship Coordinator, whereby she helps to facilitate successful experiential learning opportunities for 100+ third year GCM students. Diana is also a columnist for Graphic Arts Magazine (www.graphicartsmag.com) and she has written over 50 articles for the magazine since 2008 on a variety of topics including: print technology, communication trends and innovations, management and social media for business. Diana is currently pursuing her Master of Arts in Communications & Technology at the University of Alberta.

New Aspects of Print Simulation Training in Higher Education

Eva Paap
Stuttgart Media University

paap@hdm-stuttgart.de

Keywords: Simulation Training, Printing Technology, Education, Software

As the world of media is rapidly changing, printing technology still remains an important part of many study courses. Yet often university funding is utilized for newer media applications rather than for purchasing new printing equipment. Many students are entering their upper levels of education without ever having seen a printing press or having been inside a printing company, yet are expected to gain knowledge in these areas in order to work in management positions within the print media industry upon graduation. Simulation training enables universities und institutions of higher learning to train students in a time and cost effective manner in a range of printing technologies. The Stuttgart Media University has been successfully using simulation training in the areas of sheetfed offset printing and web offset printing for 12 years now. The presentation shows the detailed utilization of simulation training at the Stuttgart Media University and would include positive and negative aspects of simulation training, IT and trainer requirements, student and alumni reactions and recommendations for further software development. Furthermore the various courses and their structure are depicted. Particular focus will be placed on the benefits of simulations training and how an institute of higher learning can integrate this into their curriculum. Screen shots of the software are integrated into the presentation. A live demo of the software could be included as well. The Stuttgart Media University uses simulation software from Sinapse Print Simulators, manroland web systems as well as ABB. Other simulation software is also used for management case studies. Additionally, the university has two live press consoles on which print simulation software runs. Printing technologies will remain an important industrial sector for which qualified professionals are required. Granted, the industry is shifting, but many areas will remain relevant, and production of paper continues to remain stable worldwide. Universities need to supply skilled and competent graduates for this industry and simulation training offers an inexpensive alternative to traditional equipment in the educational sector.

Analysis of the optical characteristics using multi-spectrum luminescent inks

Juozas Margelevičius, Daiva Sajek, Virginijus Valčiukas
Kauno kolegija/University of Applied Sciences (Lithuania)

1. Introduction

Luminescence is emission of surplus energy in the form of light caused by induction. A large group of gaseous, liquid, and solid as well as organic and inorganic materials are luminescent in nature. Nature of the luminescence process essentially depends on the physical state of the material and induction type. The luminescence effect is applied in information visualisation, electronic and microelectronic products, light techniques, etc. Luminophore is a substance that exhibits the phenomenon of luminescence. Luminophores are used to cover continuous or targeted surfaces or to modify materials.

Luminophore absorption and emissivity are associated with Stokes-Lommel law, stating that the wavelength of photoluminescence is greater than the wavelength of the exciting light. For instance, after UV luminophore is exposed λ = 254 nm, λ = 312 nm or λ = 365 nm, it emits visible light. Yet, there is an exception to Stokes-Lommel law, the so-called 'anti-Stokes' luminophores, when induced by IR (Infrared, λ = 980 nm exposure) emit a visible spectrum.

In printing, luminophores are used as pigments for specialty inks designed for product-authentication tags, document security features, logotypes, and brands. Recently, luminescent inks possessing 'Stokes and anti-Stokes' features have been designed for the specialty printing. To prevent thermal effects and enhance maintenance, the inks can be covered with a transparent polymer coating or a lacquer. All these affect the intensity of the luminescence emission as well as wavelength. The diffusion rate is an important feature of the product, especially when these parameters are used for authenticity check.

Since the luminescent inks with UV and IR exposure excitation have been introduced into the printing industry recently, there has been a lack of relevant information in the scientific resources. Spectroscopic and colorimetric analysis aims to assess the change of the optical parameters of the luminescent inks under different UV (λ = 254, 312, 365 nm) and IR (λ = 980 nm) wavelength exposure. Experiments aim to combine the two (Stokes and anti-Stokes) principles of luminescence.

2. Methods and equipment

In order to evaluate the material (luminescent printing inks), the adequacy and an effective use of identifiable products, it is necessary to identify major controllable physical criteria. The luminescent material /inks are characterized as follows:

1. Spectrum emission (spectrum composition and distribution of energy exposure wavelengths);
2. Absorption spectrum (dependence of the absorption coefficient on the wavelength);
3. Luminescence intensity ratio (excitation and energy exposure rate);
4. Kinetics of the luminescence process (change of luminescence intensity based on external influences).

The two characteristics that are crucial for the authenticity control are the composition of the spectrum emission and distribution of intensity. Other characteristics are less relevant for the analysis. The main physical characteristics are associated with many factors, including the characteristics of the exposure excitation.

Movement of the electrons from one energy level to another occurs during the process of the material illumination. The distance between energy levels depends on the structure of molecules. Part of the exposure energy E_0 is consumed for temperature, absorption and other processes-w, whereas the other part is emitted in the form of the photons. Exposure of the photon energy will always be lower than emitted in hυ, therefore energetic luminescence expression obtains the following form: $E_0 - E_1 = h\upsilon^* + w$, where h-Planck's constant, υ^* – absorbed light oscillation frequency.

It is inconvenient to evaluate the efficiency/quality of luminescence using energy levels, thus the intensity of light is used as measure. Luminescence intensity ratio I to the exposure (excitation) intensity I_0 is the

luminescence efficiency coefficient $K=I/I_0$. Relative values are convenient not only in evaluation of the quality parameters, but also in performing of the metrology tests.

The sample of the luminescent ink QFX was analysed using the videospectral comporator Foster + Freeman model VSC5000 - an automated system of the print analysis (Figure 1**).**

Figure 1. Video spectral comporator VSC5000

Comporator VSC5000 captures reflected, absorbed, and fluorescent spectrum of the wavelengths and relative intensities of the emission at the discretion of 10 nm. Various wavelength λ of exposure including 254 nm, 312nm, 365nm and 980nm were used for the sample illumination. Luminescence measurements were performed on the print samples including plain paper and paper covered with a 50μm PC laminating coating.
Available laminating coating has an impact on the change of the luminescence characteristics. The laminating technology itself is related to thermal effects. The hot embossing requires temperature range 90–110 ºC. The issue of the thermal effect becomes more urgent when the product is multi-layered, e.g. identification cards (ID) that may have five or more layers. The layers are collated and fused under pressure at high temperature until polymer reaches a glass transition temperature. Due to the different types of polymer, the temperature is subject to change respectively. Technological characteristics usually are determined while experimenting. Presently, the production of ID cards widely employs polymer-polycarbonate (PC). Its glass transition temperature compared to the other polymer is relatively high – 170–200 °C, depending on the PC brand. Therefore, the luminescence phenomena is influenced by high temperature exposure. Experiments were carried out to determine different effects of temperature on the characteristics of the luminescence emission. The experiments involved the analysis when the samples were heated by the controllable temperature source, and the spectra were measured by the comporator VSC5000. Spectrogram I = f (λ), chromaticity x-y diagram and CIE L * a * b evaluation system are used in the result analysis.

3. Outcomes of the analysis

QFX inks combine Stoke and anti-Stoke luminescence, induced by UV and IR exposure. Typically Stokes UV luminescence occurs at three different UV wavelengths: 254 nm, 312 nm and 365 nm, and the anti-Stokes luminescence at 980 nm exposure. The main parameters characterizing the efficiency of inks are as follows:

1. Intensity of the luminescence emission;
2. Contrast of the transmitted light wavelength at different wavelengths of the exposure;

Samples of the spectrogram at UV and IR exposure without protective coatings and with a 50 μm PC coating are shown in Figure 2.

It is evident from the figure 2 that in the presence of the three different wavelengths, UV and IR luminescence exposure of the spectra are not in a particular range, but they consist of several different λ components. It means that visually observed colour is not a part of the colour spectrum, but a mix of two or three colours. The first component of the spectrograms is about 410 nm (blue colour), the second 520–570 nm (green colour), and the third 640 nm (yellow colour). Such distribution of the luminescence spectrum with a complex and relatively broad emission does not produce a solid contrasting colour. Visible luminescence colours are visually similar and close within the optical range as evident in the chromaticity x-y diagram (Figure 3).

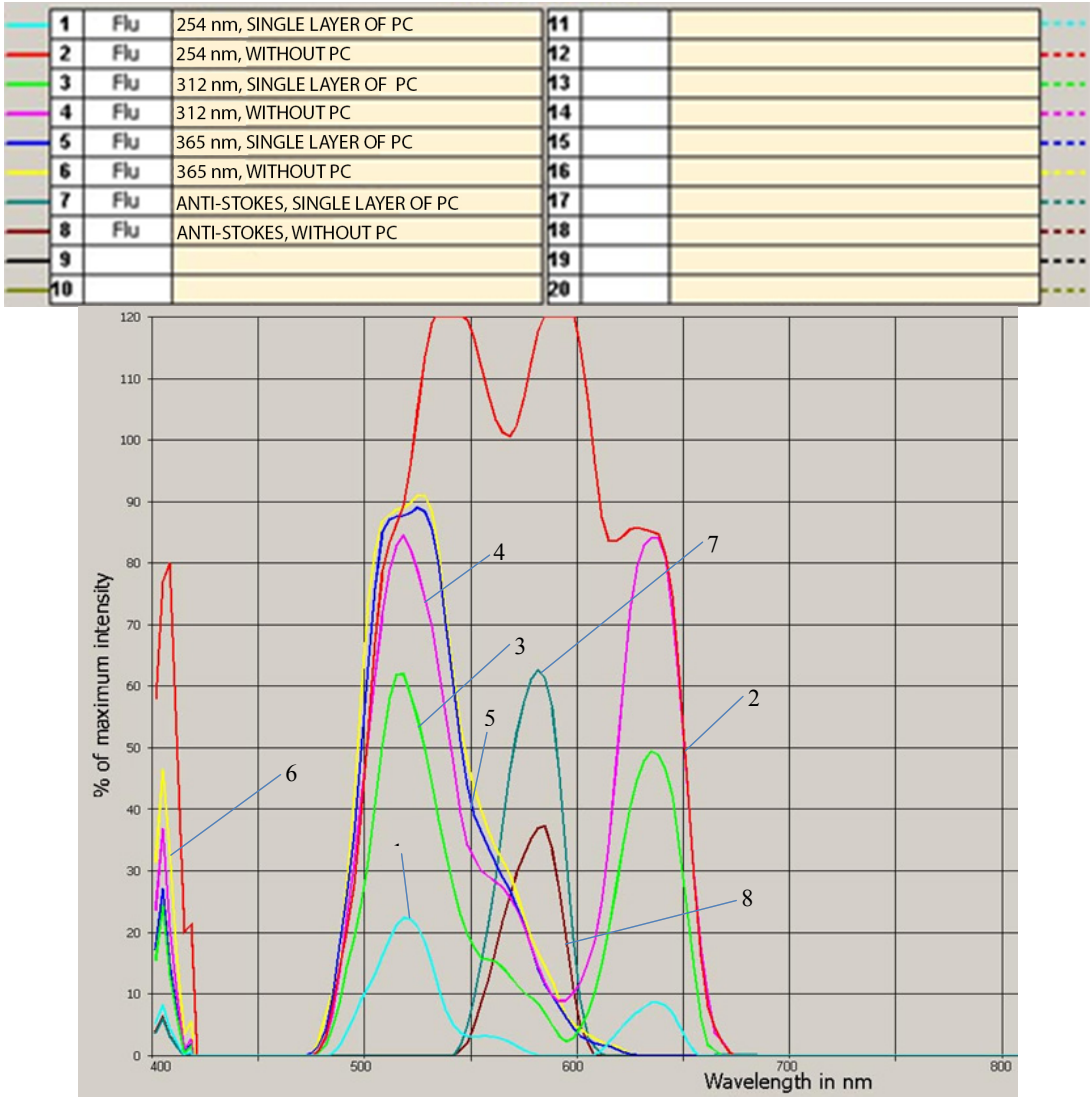


Figure 2. The spectrogram of the sample luminescence. UV exposure – 245 nm, 313 nm, 365 nm; IR exposure – 980 nm. Spectrogram – 1, 3, 5, 7 – with a 50 μ PC laminating coating; 2, 4, 6, 8 samples without coating.

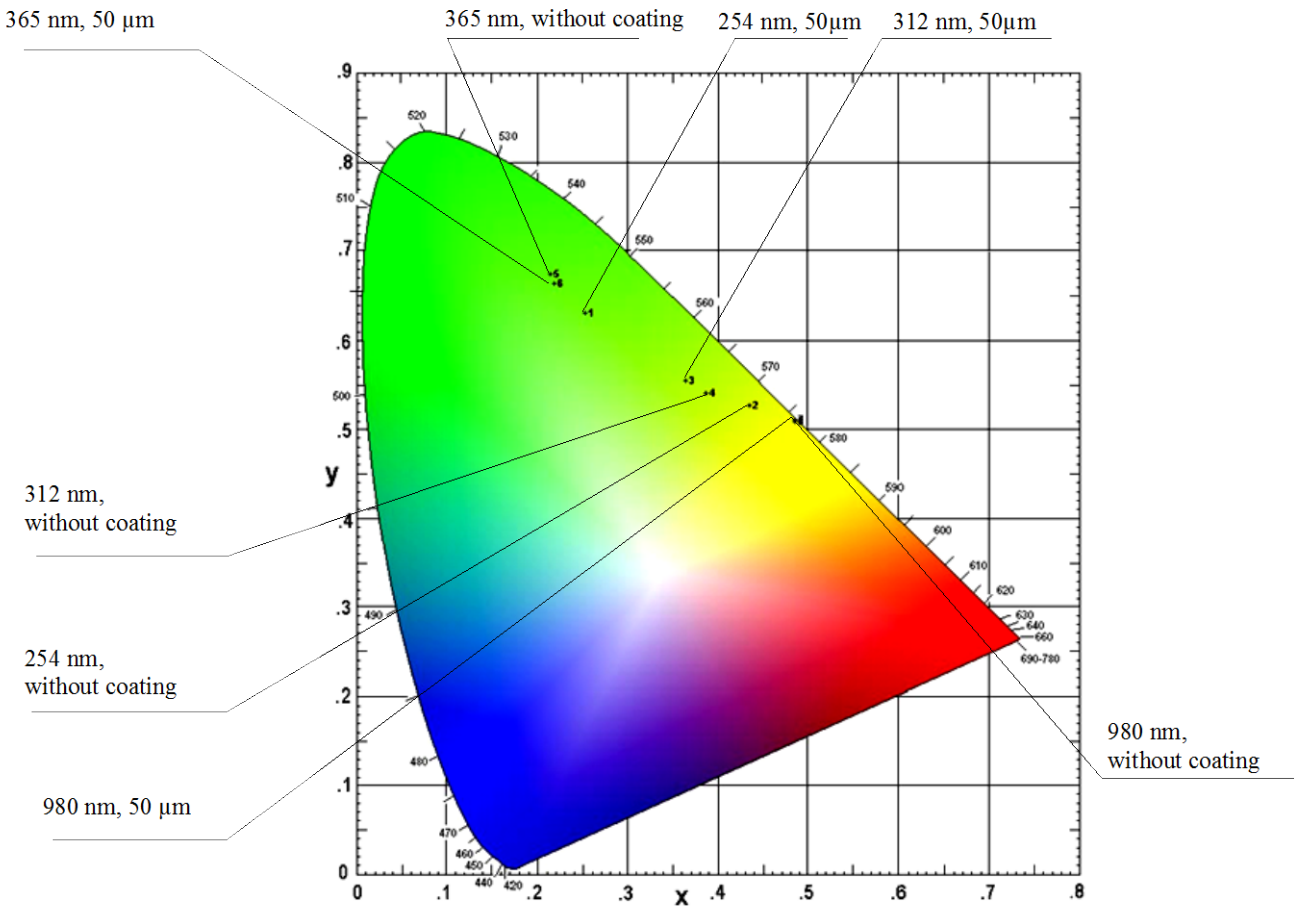


*Figure 3. The chromaticity **x-y** diagram of the sample luminescence*

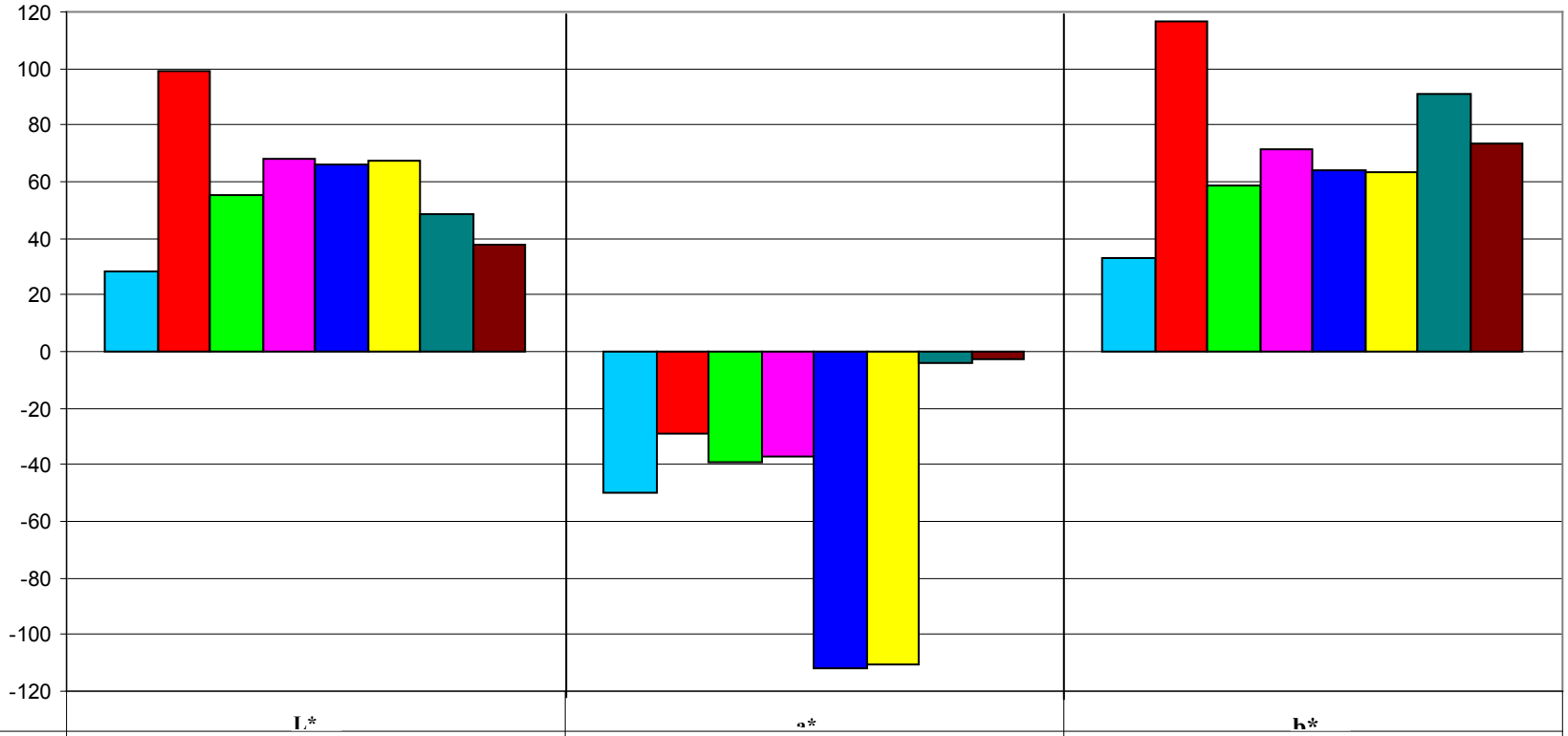
Protective coating reduces the intensity of the luminescence emission as well as width of the spectrum. Decrease in the luminescence spectrum also depends on the wavelength of luminescence exposure. In the presence of the exposure at 254 nm, the luminescence emission is reduced 6 times, meanwhile an increase of the exposure wavelength is up to 312 nm, luminescence through the PC protective coating is reduced up to 0.65 times compared with the luminescence without a coating. Meanwhile, in the presence of the luminescence of 365 nm UV exposure, the coating has almost no effect on the intensity of the luminescence emission. At the anti-Stokes luminescence (980 nm exposure), a PC coating decreases the emission intensity approximately by 0.6 times. The intensity of the luminescence UV emission range is very different. It largely depends on the exposure wavelength. Maximum intensity of the luminescence emission is produced at 254 nm exposure. The average λ = 312 nm and λ = wave 365 nm UV exposure causes a similar intensity of the luminescence. However, its intensity is about 0.7 times smaller than at the 254 nm exposure. Very similar results are obtained at 980 nm exposure (anti-Stokes luminescence). The luminescence intensity decreases slightly (approximately 10%) compared with the 365 nm exposure. The luminescence spectra are measured as the surface is covered with a 50 μm polycarbonate (PC) coating under the same exposure conditions.

The experiments applied a PC coating exclusively, therefore it is not possible to determine the nature of the luminescence intensity loss. This requires further investigation, yet it is evident that the major impact is associated with the wavelength of the exposure. It should be noted that the PC coating not only reduces the luminescence intensity, but changes its frequency response. In addition, changes are observed in the intensity (luminescence) of light colour. Frequency response also depends on the exposure wavelength.

Luminescence spectral change is an undesirable phenomenon for the authentication control. Especially when luminescence colours are very thin at the different exposure and the protective PC coating alters its optical characteristics. It is possible to apply different wavelengths of the UV exposure for any sophisticated graphics solutions at low contrast. Low luminescence contrast in different wavelengths of exposure is demonstrated in the chromaticity xy diagram (Fig. 3). As the marked comporator VSC5000 points demonstrate, the dominant colours of the luminescence emission are green and yellow contrary to the provided characteristics by the manufacturer.
Colouristic distribution was measured by the Lab system. Results obtained from the previous measurements (Fig. 2 and Fig.3) were confirmed on the basis of the change diagram of the CIE L * a * b * scale. Test samples for luminescence colour coordinates without protective coatings and their changes when using the PC 50μm coating are displayed in Table 1 and Figure 4.

Table 1

Number	X	Y	Z	x	y	L	a	b
1	0.023	0.057	0.01	0.255	0.629	28.6	-49.9	33.1
2	0.821	0.983	0.069	0.438	0.525	99.3	-29.1	116.7
3	0.154	0.232	0.033	0.367	0.553	55.3	-39.3	58.5
4	0.278	0.384	0.051	0.39	0.539	68.3	-37.0	71.3
5	0.114	0.355	0.059	0.216	0.673	66.1	-111	63.9
6	0.125	0.375	0.066	0.221	0.662	67.7	-110	63.3
7	0.164	0.171	0.001	0.488	0.509	48.4	-3.9	91.1
8	0.095	0.099	0.001	0.488	0.507	37.7	-2.9	73.7



	L*	a*	b*
254 nm, 1 sl. PC	28,6	-49,9	33,1
254 nm, be dangos	99,3	-29,1	116,7
312 nm, 1 sl. PC	55,3	-39,3	58,5
312 nm, be dangos	68,3	-37	71,3
365 nm, 1 sl. PC	66,1	-111,7	63,9
365 nm, be dangos	67,7	-110,6	63,3
980 nm, 1 sl. PC	48,4	-3,9	91,1
980 nm. be dangos	37,7	-2,9	73,7

*Figure 4. The diagram of the colour coordinate alteration in the CIE L*a*b* scale*

The coordinate L (Fig. 4) shows the observed emission brightness (luminescence) which is proportional to the observed intensity of the luminescence emission. Coordinates a and b express changes in colour of the observed image. As seen in Figure 4, the PC coating suppresses the luminescence emission in the presence of the UV at 254 nm excitation wavelength. In this case, the total observed luminance of the colour/brightness decreases from 99.3 to 28.6 relative units. Moreover, the alteration and increased brightness in colour tone was observed. This evident from the coordinate point one in the x-y diagram with the PC coating and the point two without the coating. The lower change of the luminescence spectrum is observed when the wavelength of the UV excitation is greater, e.g. 312-nm and 365 nm. It should be noted that the difference is closely correlated to the UV excitation wavelength. The intensity of the luminescence emission increases with the increasing wavelength simultaneously, it means that the image observed becomes visually brighter. Furthermore, the colour change is less significant. Analysing the impact of lamination in luminescence at excitation of 980 nm, it is evident that all different methods of measurement are significantly correlated, that is, they are similar in nature. It can be argued that the changes are minimal in regards to the emission rate at IR exposure (anti-Stokes luminescence) and the tone of the observed colour tone using a laminate coating. The same applies to the 365 nm UV exposure. It means that close UV range (254 and 312 nm) exposure for the luminescence excitation provides good results.

Due to its thermal effect (temperature ranges from 90 to 110 °C) laminating technology as well as laminate coating may alter the luminescence characteristics. Polycarbonate (PC) is a commonly used material in the laminating process. Its glass transition temperature compared to the other polymers is sufficiently high – 170–200 °C. Therefore, here we encounter the phenomenon which affects luminescence, i.e. thermal effect, as proved by the carried out experiments. The experiments were conducted based on the same methodology. The sample was heated by a controllable temperature source, and spectra were measured using the comporator VSC5000 (Fig. 5).

The analysis of the spectrograms (Fig. 5) revealed that at different λ excitation, maximum values of the luminescence spectra do not change their wavelength of light. Thermal effects narrow peaks of the light spectrum in comparison with the spectra of the non-heated sample. Colour of luminescence becomes more solid. But *I* luminescence varies depending on the thermal effect, and at the UV excitation thermal effect is more significant. IR range of the λ = 980 nm excitation of the sample after exposure to heat luminescence intensity does not diminish, but increases. Heating enhances the luminescence effect [4]. Increase in luminescence *I* is proportional to the increase in temperature and is significant in the relative value. In addition, relaxation processes should be taken into consideration. [5]. It means that within a particular period, luminescence intensity may decrease. The results of the thermal effect on the print with luminescent inks correlated to the light (luminescence) emission intensity *I* are presented in Table 2.

Table 2

Wavelength of the excitation luminescence ,λ	Change in the luminescence intensity (-,+) %, after thermal effect of the print		
	50 ºC	100 ºC	170 ºC
254 nm	-21	-27	-37
312 nm	-14	-31	-47
365 nm	-23	-33	-77
980 nm	+24	+29	+29

Luminescence intensity changes affected by temperature are subject to evaluation when selecting luminescent inks and temperature required for the lamination process. The product with the luminescent protection can be very difficult/unreliable to identify after the technological operations, which require a higher temperature, due to insufficient luminescence intensity.

An important characteristics of the luminescent inks is that after the thermal effect in the process of excitation, colours of the luminescence emission would be restored. Coloristic properties/colour changes are provided in the chromaticity xy diagram. The colour coordinates without heating and after heating of the print up to 170 °C, at UV and IR luminescence exposure after excitation are presented in Figure 6.

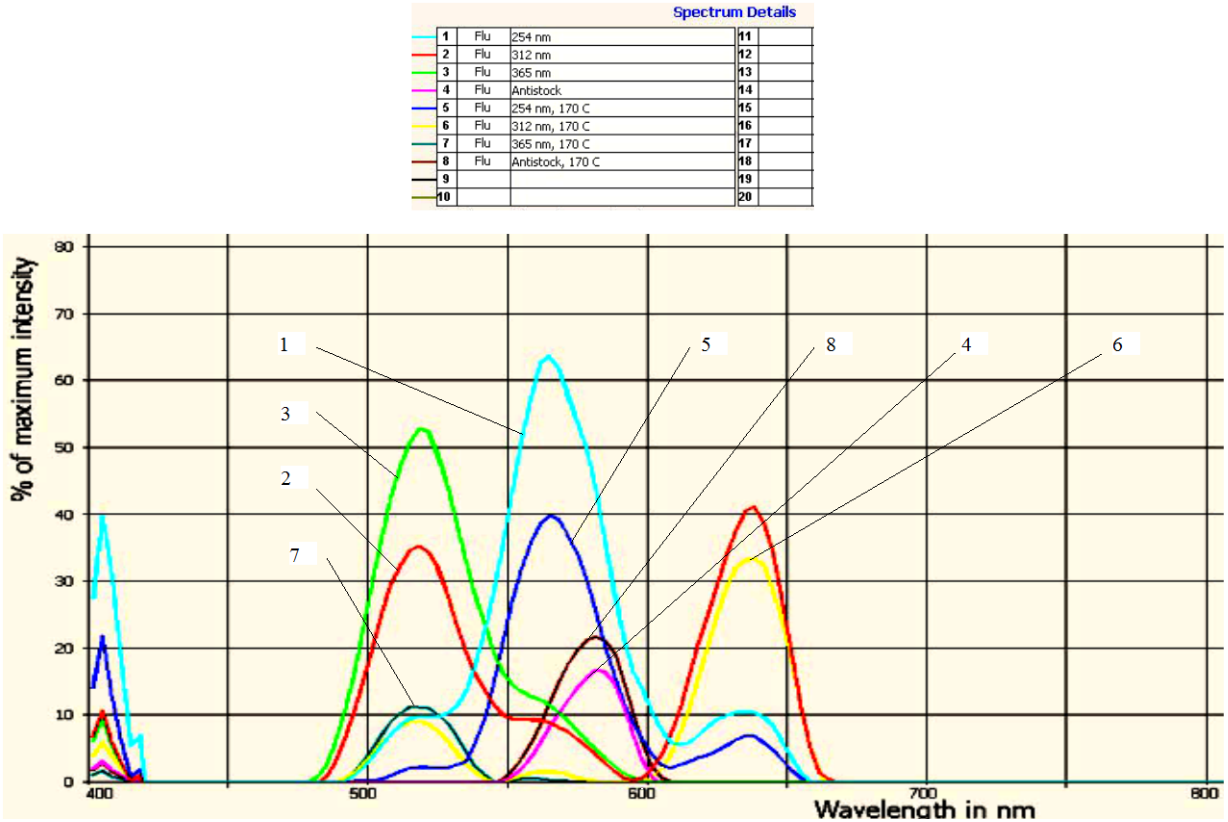


Figure 5. Spectrograms of the luminescence sample. UV exposure under normal conditions – 245 nm (1), 313 nm (2), 365 nm (3). IR exposure under normal conditions – 980 nm (4). UV exposure after heating at 170 ºC – 245 nm (5), 313 nm (6), 365 nm (7). IR exposure after heating at 170 ºC – 980 nm (8)

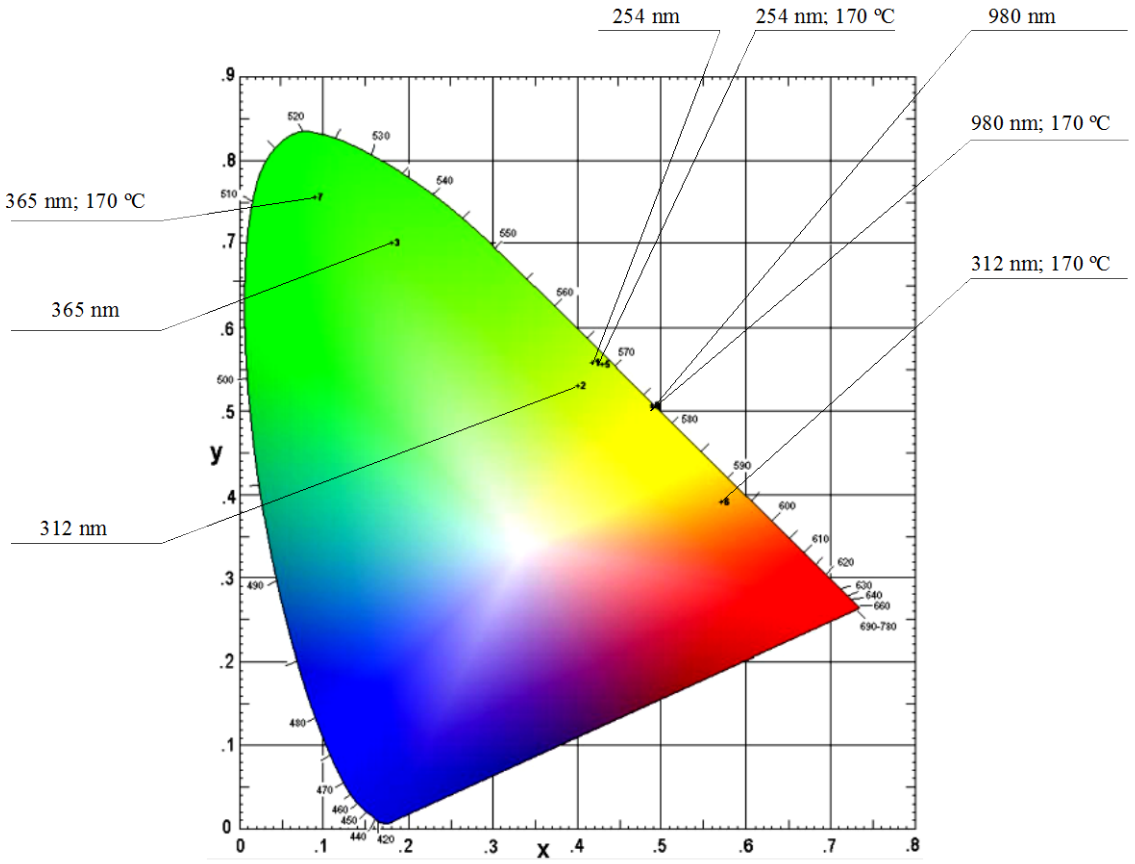


*Figure 6. Chromaticity **x-y** diagram under normal conditions and after heating at 170 ºC*

As seen in the diagram (Figure 6), when excited by 312 nm UV exposure there were significant changes in the luminescence wavelength/colour. The change depends on the temperature. When the print is heated to 170 ºC, colour moves in the direction of longer wavelength (red c), meanwhile at 365 nm excitation, luminescence wavelength slightly decreases.

4. Outcomes

The obtained results suggest that the colouristic characteristics of luminescent inks may be contrary to the ones declared by the manufacturer. In order to fully assess the durability of inks and identification level, the long-term reliability of ultraviolet effects (solar radiation) and relative humidity should be determined.
The laminate significantly reduces the luminescence at λ = 254 and 312 nm excitation wavelength exposure (81% and 27% respectively). Given such loss of luminescence energy, the product lamination becomes undesirable.

When the heating temperature of the print is increased, luminescence emission significantly decreases. For example, at 170 °C the emission may be reduced to 37–77%. Luminescence intensity decreases while increasing UV exposure / excitation wavelength. For example, after heating the print to 170 °C, excitation λ = 254 nm UV luminescence is reduced to 37%, while at the UV excitation λ = 365 nm, luminescence intensity decreases to 77%. For these reasons, hot lamination for the products with the luminescent inks QFX with the identifiable elements is not recommended.

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Infrared colorants as twins for security printing of documents and securities

Ivana Žiljak Stanimirović [1], Jana Žiljak Vujić [2], Maja Matas [3]

[1] *Assistant Professor, PhD, University of Zagreb Faculty of Graphic Arts, Croatia*
ivana.ziljak.stanimirovic@gmail.com

[2] *Assistant Professor, PhD, Polytechnic of Zagreb, Croatia*
janazv@tvz.com

[3] *PhD student, University of Zagreb Faculty of Graphic Arts, Croatia*
majamatasid@gmail.com

Keywords: CMYKIR separation, Z-regression, colorant twins, camouflage reproduction, near infrared spectrum in the press

Abstract

Twin colorants are demonstrated in the technology of mutual concealment of two integrated graphics printed together in the same place. We set up a double reproduction state with a given mathematical model for SWOP colorsetting which is suited for colorant management in two spectrums: the visual and near infrared. Double portrait images, face and profile, in one print but each separately identifiable; or in a visual or infrared light spectrum. Development of dye twins that have the same visual values (L * a * b / RGB) and different values of Z [1] is the starting point for calculating the Z-regression. Proposed is a new mathematical model Z-regression as a special form of CMYKIR separation [2]. The aim is to calculate the colorsetting with a fixed value of the coverage of the K channel, and for all the color tones. Sets is a new algorithm that will allow the calculation of the value of X_{40} for all dye color tones and their replacements of X_{40} depending on the X_0.This is a completely different approach to separation and has its own purpose: the set value K before separation C, M, Y allows the creation of a hidden image into a reproduction, that is not visible to the human eye but that becomes visible with the use of infrared glasses. Printing with process colors in the conventional raster technology is designed for multicolor protective press. Recipes are given for mixing of process CMYK colorants for creating the SWOP twins which the Z-regression can use to produce spot colors with applications in the security printing, with the title „camouflage reproduction“.

Introduction

Difference between the GCR and the CMYKIR method

In the separation with the GCR method, every same color tone in the picture will be joined by the same transition solution from RGB to CMYK. For example: SWOP (coated) / for RGB = 115,99,65 ; L*a*b = 44,5,25 will join : CMYK 0,17,34,63 for maximum setting of the GCR separation. This will be done for all pixels A_1, A_2, ... A_i with the same RGB values in the whole image.

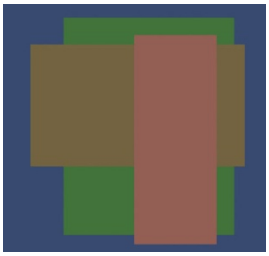


Figure 1. Four color graphic with the corresponding data in Table 1

Table 1. The values of the conventional separation of SWOP (coated) colorsetting

Name of the dye	RGB (0 – 255)	L*a*b	cyan, magenta, yellow, black SWOP (coated) %					
			none	light	medium	heavy	maximum	40% K
blue	56,74,112	30,-1,-28	86,67,36,0	91,61,24,24	88,56,17,32	83,49,9,41	69,34,0,59	84,50,8,40
green	66,115,59	42,-40,.27	81,42,85,0	83,28,04,20	82,25,93,23	79,17,91,30	74,0,87,42	75,2,88,40
brown	115,99,65	44,5,25	56,61,74,0	48,56,80,21	37,48,73,34	17,32,54,52	0,17,34,63	31,44,70,40
brick	147,95,84	48,28,20	37,68,56,0	31,68,62,12	24,66,57,19	17,63,53,26	0,57,42,39	0,56,41,40*

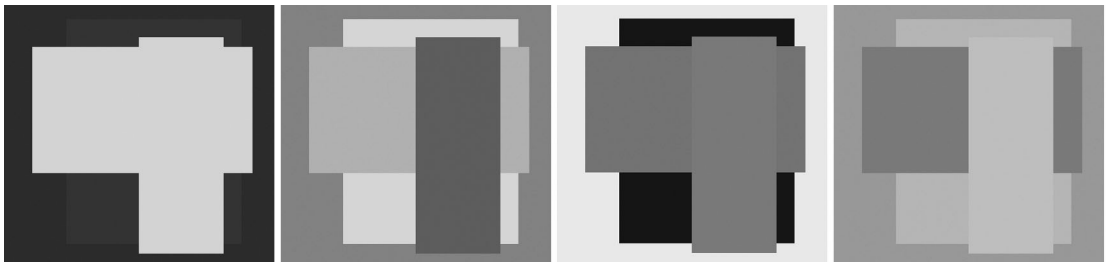


Figure 2. Substitute CMY with K for GCR heavy, SWOP (coated)

The difference to the CMYKIR separation: The value of K channel is set in advance for every pixel separately, before the separation. Figure 2. The value of Z is the information coming from the external image that has become a guide principle for the future K channel. Every pixel from the vector A_i with the same RGB will be joined individually with a different solution. If, for example, the predetermined (example RGB 115,99,65) K is equal to 40% then the composition of the dyes on the pixel A_1 will be (CMYK) 31,44,70,40 %. If the coverage of K is set independently on the same color tone on the pixel A_2 with K = 0% then the solution will be (CMYK) 56,61,74,0%.

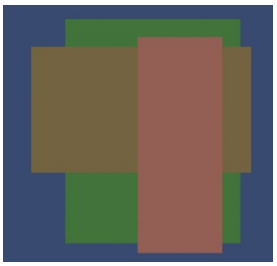
RGB  + Z 

Figure 3. Preparation for the CMYKIR separationthat connects two graphics

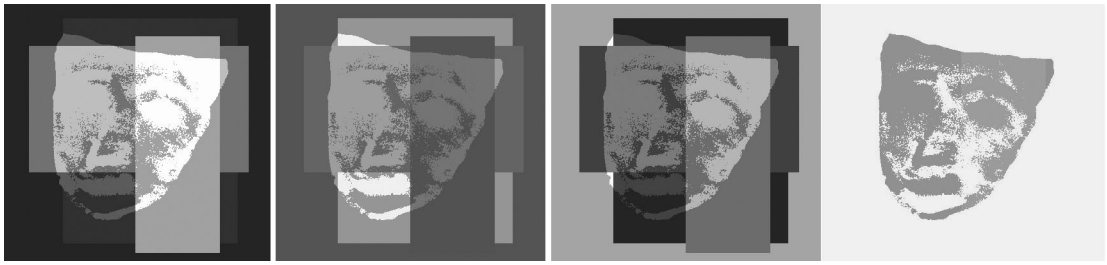


Figure 4. CMYKIR separation

As in the conventional CMYK separation (Fig.2), and in the CMYKIR separation (Fig.4), the reproduction will not visually show the K channel. In the CMYKIR separation the K channel will be visible only when we look at the image with a infrared camera. Specifically, carbon black dye has a strong absorption in the infrared spectrum. In the infrared spectrum, as seen with a surveillance ZRGB camera or other IR camera, the cyan, magenta and yellow component will not be visible in in reproduction [4].

Colorant twins X_0 i X_{40}

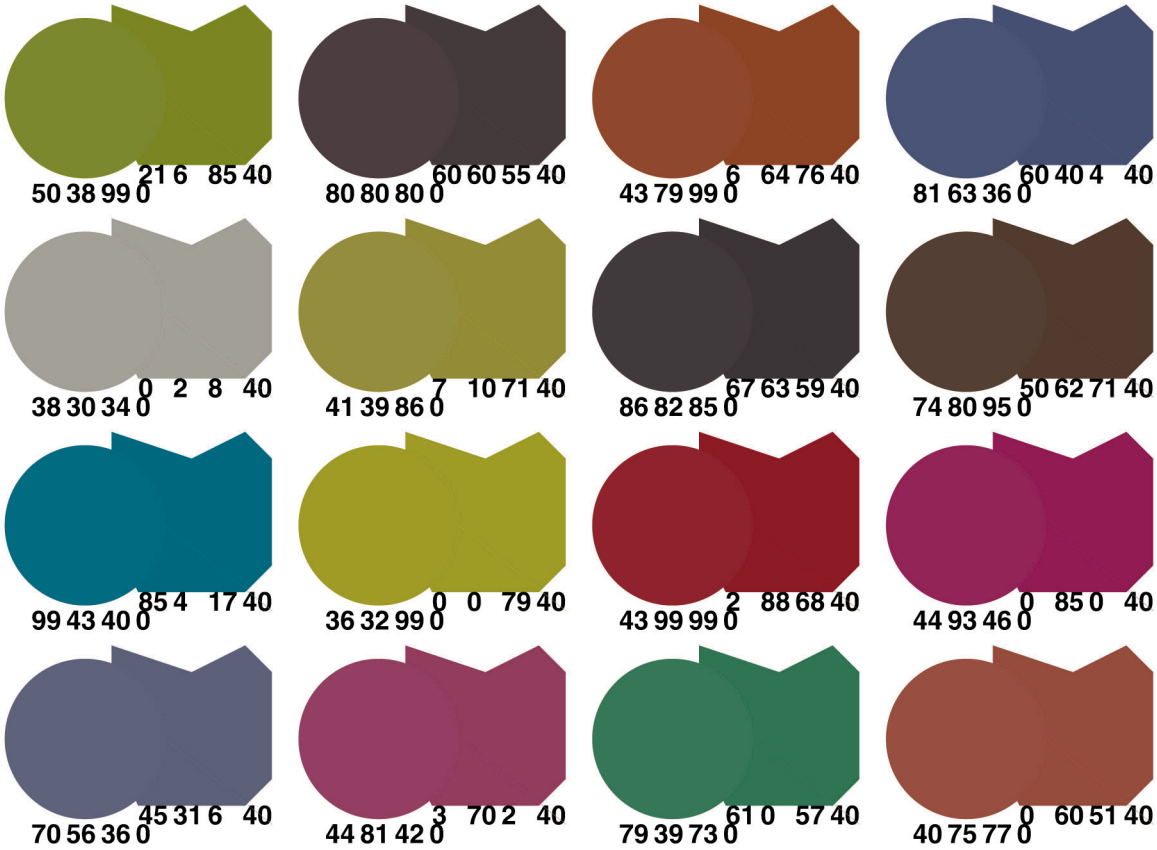


Figure 5. Colorant twins for X_0 and X_{40}

The offered set of a dozen twins will be used as input values in the regression analysis and calculation of parameters in relation (5). We get a unique raster printing procedure for determining the pixel state at 40% carbon black channel coverage. The printing results are given in the system of SWOP (coated) dyes. For this there are colorsettings published in several software packages for image processing. This allows a path for the reader to prove the usefulness and value or the CMYKIR [2] separation.

Mathematical model of the CMYIR separation

C_0 (cyan), M_0 (magenta), Y_0 (yellow) in the pixel coverage percentage are the only input data for calculating CMY values ranging from zero to 40% coverage of the Image Z. These values occur in the conventional separation RGB / CMY with the option „non“. Already in the first research of C, M, Y in the dependence of the carbon black colorant K, it was revealed that this replacement is very complex. After publishing several mathematical models, we propose here a new extended model. There are three independent variables introduced D, E, G derived from C_0, M_0,Y_0 (X_0). The regression model is derived from the materials for "twin color" for a wide range of tones. Only six independent variables created an acceptable reproduction that performs the twin at 40% coverage of the carbon black dye. It starts from the recommendations of the graphic colorimetrics differentiating twins with a less than three value of "delta E". Under D_C, E_Y, G_M imply their status on the basis of the initial value X_0. The model uses the connection of each component of C_0, M_0, Y_0 with the other two, in this matter:

$$D_C=C_0/M_0 +C_0/Y_0$$
$$E_Y= Y_0/M_0 + Y_0/C_0 \quad ; (1)$$
$$G_M= M_0/C_0 + M_0/Y_0$$

The relations are set:

$$X_{40}=A^{SWOPc} * T \ ; (2)$$

Where A^{SWOPc} denotes a matrix of data on 40% coverage of carbon black dyes.

$$X_{40}=\begin{bmatrix} C_{40} \\ M_{40} \\ Y_{40} \end{bmatrix} \ ; (3)$$

$$T=\begin{bmatrix} G_M \\ E_Y \\ D_C \\ Y_0 \\ M_0 \\ C_0 \\ 1 \end{bmatrix} ; \ (4)$$

Linear regression calculated values of the parameters for SWOP (coated) colorant:

$$A^{SWOPc}=\begin{bmatrix} -1.9340 & -0.7478 & -0.86834 & 0.044974 & -0.09348 & 1.44131 & -45.3458 \\ 2.2555 & -3.5720 & -3.35072 & 0.058569 & 1.1658 & -0.1079 & -19.9197 \\ 1.3566 & -4.3658 & -0.60741 & 1.14366 & -0.47218 & 0.04335 & -19.3569 \end{bmatrix} ; (5)$$

Rasterizing system was set at 40% coverage. These relations are not used for coverage above 40%. Extensive experiments measuring the infrared spectrum showed that the hidden image is sufficiently recognizable as the default graphics with 40% of Z. Therefore, the value of the coverage graphics Z is continuously reduced to the maximum opacity of 40% before the CMYKIR separation. Darker and lighter areas are obtained as a condition between X_0 and X_{40}.
The distance of the final X (CMY) state is set for Z coverage of each pixel:

$$X=\begin{bmatrix} C \\ M \\ Y \end{bmatrix};$$

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} C_0 \\ M_0 \\ Y_0 \end{bmatrix} - (Z/40)* \left(\begin{bmatrix} C_0 \\ M_0 \\ Y_0 \end{bmatrix} - \begin{bmatrix} C_{40} \\ M_{40} \\ Y_{40} \end{bmatrix}\right) ; (6)$$

The paper change and original dye change requires new recepies for dye composition resulting from the process range. The criteria decision of twins "visual equality" is based on the minimization procedure of Delta E, $\Delta E < 2$. The discussion extends to the press when the same twins use two different types of paper: coated / uncoated, for example. It turns out that it is necessary to implement re-press and the assessment of new twin recipes. For each combination of "paper / CMYK colorant" a new recipe for dye mixing is defined which will result in the new parameters of Z-regression.

Experiments with a double portrait

The two state-Z separation is demonstrated in a portrait. The reproduction has two images: face and profile. The profile is hidden from the naked human eye and is in infrared - 1000 nm. The two states of reproduction protect each other. The reproduction carries two independent information. In this example, the information have a connection. Face and profile are from the same person. Profile picture will be identified with IR glasses.

RGB portraits:  Z profils= 

Figure 6. Two input images for the CMYKIR separation

Figure 7. C, M, Y K channels for CMYKIR separation; Jana, Ivana, Maja

Four-color print, the display of individual channels has two purposes. First: in each C, M, Y channel the influence of output Z image is shown. Only connecting all four channels "cleans" and equals the image and visually returns the image to ist initial state. In the visual state we can only experience the face portrait. Second: The reader is given an opportunity to do these experiments himself connecting channels in some of the programs like for example Photoshop. To get the visual image on the computer screen, it is necessary to use the SWOP (coated) colorsetting. Since the Z-parameters in the mathematical model are valid for the colorsetting, we suggest the reader to change colorsetting. Then the second image "appears" on the screen, more or less, depending on the "near / distance" of the two colorsettings. These experiments show the strength of the CMYKIR separation. In this prepress, the results are good only for the case of SWOP (coated) choice of color and paper. This method can be used as an absolute precision of the transition from the visual condition (RGB) to the printed state (CMYK) of the reproduction. In other words, we are talking about "the quality of separation" and the "security / originality" of printed works.

This article publishes the method of microrasterization for the channel K. The profile portrait images no. 1 (Jana) and no. 3 (Maja) are rasterized with individual raster ring (7) and sinus (8) shapes. That algorithm detail is carried out by the CMYKIR separation as an option.
It is a simulation of a multitone rasterization.

The intention is that the value of the pixel in image Z is set in only two possible states: either the X_0 or X_{40}. This ensures the absolute respect in the relation 1 to 5. Relation 6 is not in use due to fact that for many colour hues (tones) decline of value X is not linear.

Discussion

All the colors used for the documents are planed as spot colors with dual states: for the visual spectrum and invisible in the infrared and for the visual spectrum, but visible in infrared spectrum. Set are the recipes for making color "twins" that have the same visual experience of colors tones and a different feature of absorbing IR light. Setting up the theory of twins in the security printing is an extension of the system called "Z parameter" which determines the intensity of the light absorption at 1000nm [1]. The twins integrate two spectrums in the range 400-1100 nm.

Twincans are formed by mixing process colors: cyan, magenta, yellow and black. Algorithms for press in the offset press are set for SWOP (coated) standard colorants and paper. The same security printing can be addressed as a spot color where there is a special printing unit assigned for each dye. Printing with process colorants in the conventional raster technology is designed for multicolor security print, which is successfully used in the pharmaceutical industry packaging press [3].

The performance of CMYKIR separation is not dependent on the resolution and size of the reproduction format. It is shown that any intervention attempt at the separated CMYK channels destroys the effect of mutual concealment of two graphics. Any shift in the RGB system with scanning or photographing, irreversibly destroys the infrared playback state. The hidden image disappears, the information that the profile of the person is incorporated as a separate image for the infrared spectrum. This proves that the reproduction of the portrait is secured in the "dual state" through the CMYKIR separation. This principle ensures that the CMYKIR prepress cannot be copied, or otherwise forged.

There are no models that work on the CMYKIR separation. There are colorsettings which would solve hiding the default image in the K channel. The CMYKIR separation gives a controlled management solution with the K channel.

Conclusion

In the great "silence" a vast amount of surveillance cameras appeared in our environment. For this state of dual reality, we prepared a method and the development of the graphic reproduction which have a double condition: for the visual and for the near infrared spectrum, we call it infrared extended reality. We are introducing steps for precise manipulation of dyes for the purpose of mutual concealment of two images.

We set up a recipe for making color "twins" that have the same visual experience in color but a different feature of absorbing IR light. The theory of twins in the security printing is an extension of the system called "parameter Z" which determines the intensity of the light absorption at 1000nm [2]. The twins integrate two spectrums ranging from 400 to 1000 nm. Twins of different color tones are determined by the values of the coverage with the process colorants C, M, Y, K.
These values are the data for the calculation of the regression equation dependence C40, M40, Y40, and for K = 40% (X40) depending on independent variables: C0, M0 and Y0 (X0). A new mathematical model is set, developed from X0 size in six independent variables. The presented
parameters of Z-regression model relate to the SWOP (coated) dyes. There are 16 twins stated in the article, their recipes to create spot color. Twincans are formed by mixing process colors: cyan, magenta, yellow and black. With these color pairs the multicolor security press is entered that respects the visual and infrared light. The change of paper and original color requires new recipes of dye composition produced from the process range. The decision criteria of twins "visual equality" is based on the minimization of the DeltaE procedure. For twin colors that use two different paper types (coated / uncoated, for example), it is necessary to carry out re-press and determine the composition of the new formulations of CMYK colors, as well as for each combination of "paper / CMYK colors."
The success of the CMYIR separation has been demonstrated through the reproduction portraits with double pictures. In the visual spectrum face portraits are visible. In the infrared spectrum the profiles of the same person are visible. Hiding the profile is a new way of graphic reproduction, and expanded in the use of document press. The same methodology, the same algorithm, the same Z-regression equations can be applied in the general press, which should be protected, either by choice or by the order of the publisher. The infrared images are not visible with the naked eye, so they do not disturb the basic design of the publication.

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Author biography

Ivana Ziljak Stanimirovic, BSc, PhD, is a Assistant Professor at Faculty of Graphic Arts, Zagreb University.
She was born in 1978 in Zagreb, Croatia.
Ivana graduated in 2001 at the Zagreb University, Faculty of Architecture, Design Studies. In 2005 she got her Master of Science Degree and in 2007 she got her Doctor of Science Degree (PhD) at the Zagreb University, Faculty of Graphic Arts, on designing security graphics for visible and invisible part of spectrum.
Specific focus of her work is connected with security printing and inovation INFRAREDESIGN and CMYK IR separation. Up to now she has published 3 books and 4 curent contents articles; more then 60 of her scientific articles have been published in magazines and various congress proceedings (IC, PIRA,TED, Iarigai). She has participated in inovation exhibitions from USA (INPEX Pittsburgh http://www.inpex.com/special-awards.aspx), London (Diamond Award British Invention Show) via Geneve (Prix de da Ville de Geneve), Moscow to Taiwan and Malesia and she was awarded with 50 prizes http://www.infraredesign.net/ .
Many of Ivana's graphic design works are realized, such as the design of visual identities, product branding, packaging and advertising. Ivana has exhibited on 10 independent and participated in 20 design exhibitions in Croatia and abroad.
Ivana is playing violine and she has private pilot licence; Ivana is piloting and parachuting on regular basis.

Using a mobile communication device app to generate variable data prepress files

Manfred H. Breede
Ryerson University, School of Graphic Communications Management, Toronto, Canada
mbreede@ryerson.ca

Abstract

This paper discusses a software development project of a fully functional mobile communication device app for the purpose of generating variable data files to be further processed in the prepress workflow.

Applications for this type of digital files are generally found in printed products where all or part of text or image data must by definition be unique for every printed piece.

The particular example discussed in this paper are American Bingo cards, which consists of a five rows by five-column matrix, thus having 25 elements, all of which, except the centre element, are holding variable information.

In order for Bingo cards to be useful as a fair multi-player bingo game there must never be a duplicate in the way the elements are positioned on an individual matrix, as well as between inter-card matrices, thus requiring some form of variable random data generation, be it at the image assembly or image generation stage, the latter of which is used in this project.

Given that in the American Bingo game 24 unique numbers ranging from 1-75 must appear in a five rows by five column Bingo matrix, the possible numbers of combinations is 15^5 x 14^5 x 13^5 x 12^5 x 11^4, which comes to 5.52 * 10^26 or 552 sextillion. Consequently, the likelihood that the pseudo random number generator utilized for this project, produces duplicates, is for all intents and purposes infinitesimal small.

The discussion in this paper will in particular focus on the computer program architecture for this app and the vital program elements that generate and format random information; the approaches taken to render the app's output ready for a prepress workflow; possible applications beyond the product discussed in this paper, as well as the roll of mobile communication devices in the printing industry.

Introduction

According to an international team of researchers who run the real time world statistics organization *Worldmeters* the world population in 2010 was 6.8 billion [1], whereas the worldwide subscription of mobile communication devices in the same year was estimated to be about four billion [2]. Moreover, worldwide mobile communication penetration increased from 40% to 74% during the period of 2006 to 2010 alone [ibid]. Given that *Worldmeters* population figures for the years 2005 and 2010 are reported to be 6.45 billion and 6.8 billion respectively, which amounts to a five-year a population growth rate of 5.4%, worldwide mobile communication use far surpassed population growth during that period.

It can thus be said that any business sector that in one way or another could benefit from mobile communication technology would be at their own peril if such tremendous worldwide use and growth of this relatively new technology was not acted upon.

Mobile communications devices are in essence a means to reach a worldwide audience efficiently, and it is as such, useful to most if not all organizations in that it permits the promotion or dissemination of their services, products or message.

Less obvious than a mobile device's utility to promote, and disseminate services or products is their potential ability to be integrated in a manufacturing workflow, which is the subject of this paper.

Using conventional computing platforms to exploit the reach of the Internet for various functions is nothing new for the printing industry. Online activities such as FTP functionalities, direct mail and data base linking, digital asset management, soft proofing, preflighting, job tracking, payment and more, have been common in the printing industry for quite some time [3], but to date these functions are mostly executed on conventional desktop or laptop computers.

This may change, because mobile devices have changed from exclusive voice-centric to voice plus data-devices, while mobile device offshoots such as tablets do not even feature any telephony capabilities at all. As far as Internet connectivity is concerned there really is no difference between a PC and a mobile device. Both platforms use essentially the same technology. For example the *iPhone's* web browser *Safari* is the same browser that comes with the *OS X* operating system of *Apple's* desktop and laptop computers, thus providing *iOS* users with a high level of familiarity. For *Apple* product development, a single Integrated Development Environment (IDE), also called *Xcode*, is used for both *OS X* and *iOS* technologies, thus facilitating the switch from one platform to the other.

If recent sales statistics are an indication, mobile devices may in fact become the computing platform of choice. According to an article in the *Toronto Star* on April 18, 2013 global first quarter shipments of PCs were down as much as 14% [4]. In another article on April 17, 2013 the same paper reported that "*Consumers are shifting their consumer electronic dollars away from PCs and toward smartphones and tablets*" not only in the developed world, but also in emerging markets where computer usage is relatively low. Both US based research firms, *International Data Corp*, and *Gartner Inc.* more or less corroborated these trends [5].

Online entrepreneurs should take a lesson from retailers on how to capture the attention of digital users. Successful retail businesses are usually located on a city's busiest intersection. Inside stores, lucrative items are typically found in high traffic areas, or in more visible locations such as eye-level shelves, or in more convenient locations such as a hip level shelve that doesn't require too much physical effort to reach and secure items. One could call it cunning or clever, but the fact is, the psychological impulse factor to buy an item that is readily available and has a certain appeal, such as wanting to read a magazine with salacious stories of celebrities lives, or to satisfy ones sweet tooth with candies, is heavily exploited by retailers. These items are invariably located at the checkout counter.

What a busy city intersection is for a retailer is the most popular computing platform for the digital entrepreneur. Thus, if more people are migrating to mobile devices, then printing businesses must respond by showing a presence, and if possible, offer services on those devices.

The aforementioned convenience factor is of utmost importance. Nothing puts a customer off more than having to jump through hoops before a desired purchase or service can be obtained. This factor may well be where mobile devices have the greatest advantage. As the retail examples showed us, the likelihood for sales transactions to happen is much greater when obstacles to making purchase decisions are removed. Mobile devices are connecting people with goods and services more directly than any other selling mode, be it brick and mortar stores or conventional computers, simply because a mobile device will always be within easy reach of a potential customer.

Considering that mobile devices now make it possible to order a pizza, buy a cinema ticket, buy a record and listen to it, buy a book and read it, buy a game and play it, or find out in near real time where in the world the most recent earthquake occurred [6], to name but a few of the online services available now, we are definitely witnessing a shift in consumer buying habits.

If it is true that "business is the people and people is the business" it stands to reason that with such large numbers of people embracing mobile communication technology no business, if it wants to stay in business, can afford to stay aloof of such development.

Bingo Cards played on an iPhone/iPad or printed digitally as well as by offset

The heading of this section is admittedly a mouthful, but the *Bingo Card Maker* [7] app described in this paper incorporates all functions listed in it (Figure 1).

The app's User Interface (UI) consists of a typical American Bingo card image, an animation that simulates a rotating bingo cage, and four visible buttons, which allow players to make onscreen choices. In the upper left corner is an info button where players can read up on the apps' functionality. On the bottom are three rounded rectangular buttons titled from left to right *New Card*, *Spin*, and *Printable*. The UI also includes 25 custom buttons and 25 labels, which are located in the centres of each number field. Depending on the playing phase these buttons and labels are either visible or invisible, with the exception of the centre field, which always displays the title *FREE*. The purpose of the labels is to display random numbers at the appropriate playing phase, whereas the purpose of the custom buttons is to change the background of a displayed number when a player taps on it.

Figure 1. App view showing random generated numbers some of which are marked by the player.

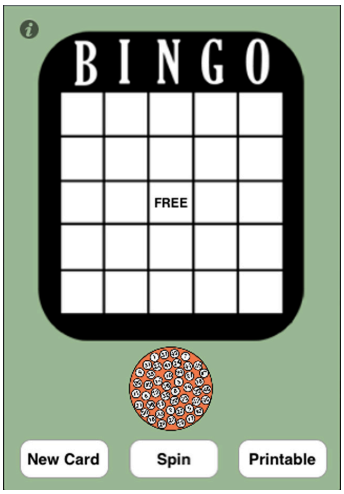

Figure 2. App view at the start of a play sequence.

The onscreen play sequence starts with a player tapping the centre button titled *Spin* (Figure 2), which sets the Bingo cage animation in motion and at the same time changes the button title to *Draw*. As a player taps the centre button again, the animation stops, the number fields are populated with random numbers, and the centre button title reverts back to its original title *Spin* (Figure 1).

With a card generated, the Bingo game can start. In the course of a game a player taps on a number when it coincides with a number called by the Bingo master. This will change the number background from white to green. In cases where a player mistakenly tapped on a number the background can be changed back to white by tapping on the number again.

Upon completion of a game, a new card is created, by tapping on the button titled *New Card*. This clears all number fields and readies the card for the generation of an entirely different set of random numbers.

Figure 3. Cropped Bingo card image ready for printing.

If a player desires to print one or more Bingo cards the button titled *Printable* has to be tapped. Once the button is tapped a cropped image of the view is sent to the *Camera Roll* of the default *Photos* app, from where it can be printed via a wireless network on a digital printing device. Alternatively, the image can be emailed and printed on a cable-connected printer (Figure 3).

Random Numbers Generating Code

The program is written in *Objective-C,* which is a pure superset of the *C* language and as the name suggests, is unlike *C*, an object oriented language [8]. It is the main language used for *OS X* and *iOS* software development. Before delving into the intricacies of the program it is useful to explain the structure of an American Bingo card itself. Referring to Figure 3, it will be seen that the Bingo card matrix consists of five columns each having five elements. All, except the very centre element are populated with random numbers. This means, all columns except the centre column have to be populated with 5 random numbers, while the centre column requires only 4 random numbers. Furthermore, it should be noted that in the American Bingo game numbers ranging from 1-75 are randomly drawn from a rotating cage.

If the Bingo card columns from the left to the right are labelled *B*, *I*, *N*, *G*, *O* then *B* holds 5 random numbers ranging from 1-15, *I* holds 5 random numbers ranging from 16-30, *N* holds 4 random numbers ranging from 31-45, *G* holds 5 random numbers ranging from 46-60 and *O* holds 5 random numbers ranging from 61-75.

It can therefore be seen that the program requires 5 random number generating code blocks, similar to the code shown in Figure 4, which is specifically relevant to column *B*.

```
1:  n = 15;

2: NSMutableArray *nummern = [NSMutableArray array];

3:  for (int i = 1; i <= n; i++) {
4:                          [nummern addObject:[NSNumber numberWithInt:i]];
5: }

6: NSMutableArray *result1 = [NSMutableArray array];
7:  while ([nummern count] > 0) {
8:                          int rand = arc4random() % [nummern count];
9:                          NSNumber *randomElement = [nummern objectAtIndex:rand];
10:                         [result1 addObject:randomElement];
11:                         [nummern removeObjectAtIndex:rand];
12: }
```

Figure 4. Random number generation code.

```
id obj1 = [result1 objectAtIndex:0];
id obj2 = [result1 objectAtIndex:1];
id obj3 = [result1 objectAtIndex:2];
id obj4 = [result1 objectAtIndex:3];
id obj5 = [result1 objectAtIndex:4];
id obj6 = [result1 objectAtIndex:5];
id obj7 = [result1 objectAtIndex:6];
id obj8 = [result1 objectAtIndex:7];
id obj9 = [result1 objectAtIndex:8];
id obj10 = [result1 objectAtIndex:9];
id obj11 = [result1 objectAtIndex:10];
id obj12 = [result1 objectAtIndex:11];
id obj13 = [result1 objectAtIndex:12];
id obj14 = [result1 objectAtIndex:13];
id obj15 = [result1 objectAtIndex:14];
```

Figure 5. Passing values from an array.

The code snippet shown in Figure 4 returns random numbers ranging from 1 through 15, using the pseudo random numbers generating function *arc4random ( )* in line 8. The max/min of *arc4random ( )* are restricted by *n* in line 1 and by *i* within the *for* loop in lines 3 through 5, where max=*n* and min=*i*. Line 6 creates the array *result1* to which the first 15 of 75 random numbers are written within the *while* loop in lines 7 through 12.

The random number generating code for the other four columns is very similar, but has to be modified by changing the min/max values *i* and *n* as follows; column *I*: *i*=16 and *n*=30, column *N*: *i*=31 and *n*=45, column *G*: *i*=46 and *n*=60, column *O*: *i*=61 and *n*=75. Since each column is randomized separately, it follows that the array *result1* must be renamed to *result2*, *result3*, *result4* and *result5* for columns *I*, *through O*.

The code snippet in Figure 5 is relevant to column *B* in the UI. It passes values from the integer-indexed *result1* array elements 0 through 14 to15 objects *named obj1* through *obj15*.

Likewise, four more columns are being passed values from matching *result2*, *result3*, *result4* and *result5* arrays, and the naming convention for the remaining 60 objects continues with *obj16* and ends with *obj75* for columns *I* through *O*.

```
NSMutableArray *tempArray1 = [[NSMutableArray alloc] init];
[tempArray1 addObject:obj1];
[tempArray1 addObject:obj2];
[tempArray1 addObject:obj3];
[tempArray1 addObject:obj4];
[tempArray1 addObject:obj5];
[tempArray1 addObject:obj6];
[tempArray1 addObject:obj7];
[tempArray1 addObject:obj8];
[tempArray1 addObject:obj9];
[tempArray1 addObject:obj10];
[tempArray1 addObject:obj11];
[tempArray1 addObject:obj12];
[tempArray1 addObject:obj13];
[tempArray1 addObject:obj14];
[tempArray1 addObject:obj15];
```

Figure 6. Creating a new array.

```
no1 = (int) obj1;
no2 = (int) obj2;
no3 = (int) obj3;
no4 = (int) obj4;
no5 = (int) obj5;
no6 = (int) obj6;
no7 = (int) obj7;
no8 = (int) obj8;
no9 = (int) obj9;
no10 = (int) obj10;
no11 = (int) obj11;
no12 = (int) obj12;
no13 = (int) obj13;
no14 = (int) obj14;
no15 = (int) obj15;
```

Figure 7. Assigning a variable to each random number 1 through 15.

```
//Column B
        bingo1.text = [[NSString alloc]initWithFormat :@"%@",no11];
        bingo6.text = [[NSString alloc]initWithFormat :@"%@",no12];
        bingo11.text = [[NSString alloc]initWithFormat :@"%@",no13];
        bingo15.text = [[NSString alloc]initWithFormat :@"%@",no14];
        bingo20.text = [[NSString alloc]initWithFormat :@"%@",no15];

//Column I
        bingo2.text = [[NSString alloc]initWithFormat :@"%@",no26];
        bingo7.text = [[NSString alloc]initWithFormat :@"%@",no27];
        bingo12.text = [[NSString alloc]initWithFormat :@"%@",no28];
        bingo16.text = [[NSString alloc]initWithFormat :@"%@",no29];
        bingo21.text = [[NSString alloc]initWithFormat :@"%@",no30];


//Column N
        bingo3.text = [[NSString alloc]initWithFormat :@"%@",no41];
        bingo8.text = [[NSString alloc]initWithFormat :@"%@",no42];
        bingo17.text = [[NSString alloc]initWithFormat :@"%@",no43];
        bingo22.text = [[NSString alloc]initWithFormat :@"%@",no44];


//Column G
        bingo4.text = [[NSString alloc]initWithFormat :@"%@",no56];
        bingo9.text = [[NSString alloc]initWithFormat :@"%@",no57];
        bingo13.text = [[NSString alloc]initWithFormat :@"%@",no58];
        bingo18.text = [[NSString alloc]initWithFormat :@"%@",no59];
        bingo23.text = [[NSString alloc]initWithFormat :@"%@",no60];


//Column O
        bingo5.text = [[NSString alloc]initWithFormat :@"%@",no71];
        bingo10.text = [[NSString alloc]initWithFormat :@"%@",no72];
        bingo14.text = [[NSString alloc]initWithFormat :@"%@",no73];
        bingo19.text = [[NSString alloc]initWithFormat :@"%@",no74];
        bingo24.text = [[NSString alloc]initWithFormat :@"%@",no75];
```

Figure 8. Selecting and displaying the strings of 5 or 4 random numbers per column.

The code snippet in Figure 6 creates a new array named *tempArray1*, which is specifically relevant to column *B* in the UI, but here again the array names for each column must be unique because they were randomized separately. Thus the array for columns *I*, *N*, *G* and *O* are named *tempArray2*, *tempArray3*, *tempArray4*, and *tempArray5* respectively. Also the naming convention for the remaining 60 objects continues with *obj16* and ends with *obj75* for columns *I* through *O*.

The code snippet in Figure 7 is relevant to column *B* in the UI, where integer values from *obj1* through *obj15* are passed to variables *no1* through *no15*. The only changes for columns *I*, *N*, *G*, and *O* is that the variable naming convention continues with *no16* and ends with *no75,* while the remaining 60 objects continue to be named *obj16* through *obj75*.

If at this point the program the output is viewed in the *Xcode* console we will see five randomly ordered number columns with 15 numbers in each columns and min/max values that are separated by 15 numbers from adjacent columns.

Since the Bingo card matrix requires five random numbers for all but the centre column, which requires four random numbers, only five or four random numbers must be selected from each of the 15 numbers arrays. Which of the elements in the arrays is selected is immaterial, as each number has an equal probability to appear in a given element. It will be seen in Figure 8 that the choice fell arbitrarily on the last five array elements and in the case of the centre column, on the last four elements.

Printing Code

Taking a screen capture and saving it to the *Camera Roll* of the *Photos* app is surprisingly simple. It is achieved by way of the *UIGraphicsBeginImageContext* function shown in line 1 of Figure 9, whereas the code for cropping the image horizontally is shown in lines 2 and 3. The effect of this cropping action is seen in Figure 3 where the three buttons on the bottom of the screen are no longer visble because the image was moved down by 50 pixels as specified in line 3. If a screen shot of the entire screen is required, lines 2 and 3 will have to be omitted.

```
1: UIGraphicsBeginImageContext(self.view.bounds.size);
2. CGContextRef c = UIGraphicsGetCurrentContext();
3: CGContextTranslateCTM(c, 0, +50);
4: [self.view.layer renderInContext:UIGraphicsGetCurrentContext()];
5: UIImage *screenshotImage = UIGraphicsGetImageFromCurrentImageContext();
6. UIGraphicsEndImageContext();
7: UIImageWriteToSavedPhotosAlbum(screenshotImage, nil, nil, nil);
```

Figure 9. Code for capturing an iPhone screen, cropping it and saving it to the "Photos" app.

Digital Printing

Because the *Photos* app has print functionalities, any image saved to it can be printed wirelessly to an *AirPrint* enabled printer. If an *AirPrint* printer is not available, third party apps such as the *Epson iPrint* app are provided free of charge by some printer manufacturers. This type of app permits wireless printing on printers that are not *AirPrint* enabled.

The third possible print option is the email functionality of the *Photos* app that enables a user to send a picture file to a specific email address. Once the email has been sent, the file can then be printed on a printer that is connected by a cable to the email receiving computer.

Analog Printing

Preparing the Bingo card for printing in any conventional printing process is possible because a jpg file is created when the Bingo card was sent to the *Photo Roll* of the *Photos* app. By assembling a composite form of several different jpg files, numerous different Bingo cards could be printed multiples-up in the offset printing process for example.

This sequence of events would be particularly advantageous for a printing company that specializes in Bingo card printing, because the app not only provides a template for a Bingo card, but also generates a near infinite number of different Bingo cards.

Likewise apps with a different purpose than Bingo cards, but also requiring randomized content, could be created. An example would be forms to be completed by recipients who for statistical reason have to be chosen randomly from a large database.

Another example is an app that takes input from a user via text fields. The information provided by the user could then be integrated in a template, or better yet, in one of many different templates, which the user selects from a table view (Figure 10).

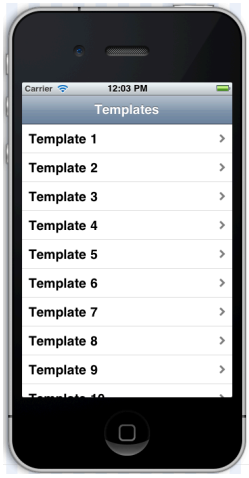

Figure 10. Proposed template choice UI.

A limiting limiting factor is the small screen size of an *iPhone*, as it will invariably cause a loss of resolution when print sizes are larger than the *iPhone 5's* screen size of 1136 by 640 pixel per inch (ppi), which at a pixel resolution of 326 ppi comes to 3.48 by 1.96 inches. Because the *iPhone 5* has coincidentally a screen size that is almost exactly identical to the 3.5 by 2 inches of American business cards, business cards or any other printed product that does not exceed the *iPhone's* screen size significantly is ideally suited for mobile device generated printing.

Larger screen sizes of some other mobile devices running on the *Android* operating system aliviate the size limitation of the *iPhone* somewhat, but the even lager screen sizes of tablet computers, though not as portable as smartphones, increases the product range considerably. For example the *iPad* screen size of 2048 by 1536 ppi is with a screen resolution of 264 ppi, 7.758 by 5.818 inches large. This size easily accomodates standard sizes such as *Organizer J* (2.75 by 5 in), *Compact* (4.25 by 6.75 in), *Index Card* (4 by 6 in), and *IOS/DIN A10* through *A6*.

Conclusion

Conducting any business, including the printing business, requires a keen awareness of peoples wants and needs, which can change with the times as new technological developments or trends influences people's habits and lifestyles.
The introduction of mobile telephony in the 1980s set in motion technological developments that saw mobile phones morph into devices more akin to a computer than a phone, which explains the moniker *smartphone* that is now often used when referring to a contemporary mobile device such as an *iPhone*.
Preceeding this development was of course the wide-spread penetration of computers in all spheres of life, including the almost total transformation of printing from an analog to a digital process.
The fact that most people now accept computers as a necessary tool for daily life made smartphones a very alluring technology, because now a person on the go could not only stay connected with the world by phone, but also by the Internet and furthermore, many of the activities performed on a computer as a matter of course, could now be accomplished without undue access restrictions, because of a *smartphone's* ever present availability in people's pockets, briefcases or handbags.
The extensive use of mobile devices is a compelling reason for almost any business to leverage at least some of their features and if a mobile device can be integrated into the very production process of a given product, such as discussed in this paper, the reasons for embracing mobile device technology are even more compelling.

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Distributed, multi-lingual learning management system for graphic industry training

Peter Herman
Sinapse Print Simlators

peter.herman@sinapseprint.com

Keywords: Distributed and lab-based learning, Computer-based learning, Internationalization

Distributed Learning Management System (DLMS) provide new ways to manage training in the graphic industry. These cloud-based, multi-lingual systems facilitate local training and remote supervision.

The presentation will explain how the combination of existing and new technologies within DLMS can provides a proactive response to structural changes to the printing industry and its training structures.

The continuing economic and structural forces on the printing industry are leading many organisations to reduce their costs and resources. This impact is strongest in mature markets in advertising/publishing-related printing, while developing markets, global packaging, and technologies such as digital and smart printing are more buoyant.

- In the developed world, commercial and publishing printing is stagnant. In many areas training classes are closing for lack of students.
- Many printing and packaging companies have cut their training budgets and no longer have trainers. The industry mantra has become: *on site* (no costly travel), *self directed* (no costly trainer), *technology driven* (computer-based, no costly press use). However, these companies still have people who need training, and newly hired staff have rarely been to a print school.
- Multi site and multi country printers want common training programs that can compare results across all sites irrespective of locations and languages used.
- Schools are increasingly looking at using their resources of experienced teaching staff, curriculum and computer-based learning with simulation to provide and manage remote training.

Therefore there is a match between the need for on-site training (of companies) and the need for a non-local trainer (from printing schools).

Print is thriving in emerging economies. However:

- Some schools may lack experienced teachers while needing to teach more students with the same number of staff by increasing their productivity.
- Graphic curricula are evolving in these regions as the focus on vocational (operator) training is now moving to education in problem solving, process control, content re-purposing and management.
- Some of these regions have academically well qualified teachers who lack practical experience, while others are ex-printers who lack a process overview, theoretical background and teaching skills.

Distributed Learning Management System tools and architecture addresses many of these issues by making available resources and data on a cloud-based, language independent platform that for the allows instructors to analyze and compare student training results automatically. This removes most of the barriers to local training and remote supervision.

Distributed learning makes it easier and more efficient to train with simulators wherever they are located. The educational server lets the administrator configure tasks, sites, groups, instructors, and trainees, each with their password, and access to results over the Internet. The instructor enrolls the trainees in the system and sets up their coursework. Trainees log on at any time at any simulation workstations in their local language. The instructor reviews in their preferred language, the results from any trainee at anytime, from anywhere. Cloud-based DLMS makes it easy for instructors to manage and evaluate large numbers of trainees and provides automatic analysis of training sessions and language-independent reports to track results by time, production cost, and ranking, to help fine tune training.
The conference presentation will present the current DLMS system and give practical examples of how it is working in different countries, the criteria by which analysis and comparisons are made, and proposals for new criteria. The interaction with other e-learning systems (SCORM-compliant) will also be addressed.

Podlicious: A High-tech Tool for Lab Instruction

Art Seto [1], Jason Lisi [2], Martin Habekost [3]

[1,2,3] *Ryerson University, Canada*

a3seto@ryerson.ca, jlisi@ryerson.ca, mhabekos@ryerson.ca

Keywords: Podcast, Educational Video, Student Engagement, Learning Styles, Lab Instruction.

Abstract

This paper explores the use of professionally made podcasts to supplement traditional teaching methods in an attempt to enhance student learning, engagement and active participation.

The graphic communications field is very technical and detailed. Lecturing and demonstrating fundamental and complex topics to students that do not have prior experience or education can be challenging.

In many post-secondary education environments, instructors must deal with increasing numbers of students in each lab section, single pieces of lab equipment, limited number of hours of lecture and lab time, complex processes and procedures to teach and a large amount of content to adequately convey and assess student's learning on. Traditional lectures do not always meet the needs of different learning styles; similarly, crowded labs can result in an unproductive teaching and learning environment where students are unable to see and hear the material being presented.

These realities led to this research project to explore ways in which podcasting technology could be used to supplement in-lab instruction for specific topics that have been historically difficult to teach. Specifically, student engagement and knowledge retention was recorded using surveys and quizzes both before and after the introduction of podcasts on subjects they had been previously taught. The question to be answered was could podcasts if produced well, have the ability to significantly enhance teaching and learning?

To fund this project, four professors in the Ryerson University (Toronto, Canada) School of Graphic Communications Management's four-year bachelor degree program, successfully competed in a university-wide funding competition. This research grant allowed the researchers to secure necessary project equipment and hire research assistants to assist with the production of the project, from script writing and story boarding, to video capture and editing, and 3D animation.

Students from the program were exposed to the podcasts on subjects recently learned in lab. Exposure to the podcasts was done in a controlled environment using iTunesU and subscription permissions. Extensive data was collected through pre and post podcast questionnaires, as well as a comprehensive follow-up survey. Subsequent research done by professors showed how students use technology (such as mobile devices and computers) and how they reacted to the use of video podcasts developed especially to teach core concepts and for the use of this research project.

The research concludes that the majority of the students found the podcasts useful in supplementing learning and enjoyed watching them as part of the course materials. They also answered that the podcasts were easy to access, due to the method used for deploying them.

Introduction

The School of Graphic Communications Management (GCM) at Ryerson University in Toronto Canada is the only degree-granting university program of its kind in Canada. The GCM curriculum offers learning opportunities for students in the areas of business management, print and non-print communication, and liberal arts studies. Although students learn hands-on how to operate dozens of specialized leading-edge pieces of equipment and software used in the graphic communications industry, it is the deep understanding of workflow and specialized management concepts that defines GCM interns and graduates. As a result, GCM has a high internship and job placement.

Courses at GCM are typically divided into lecture components with 85 to 175 students and with labs typically with 20 to 25 students. Although GCM has been successful in the past with limited teaching assistant (TA) and technical support, growing class sizes require a look at new pedagogical strategies so that the program can continue to be viable.

There are a number of challenges with teaching specialized technology to large groups. Instructors are often faced with the challenge of demonstrating abstract and foreign ideas that students have never encountered before. Students that end up in the back of the group of students crowded around a piece of equipment may not see the full demonstration. Although students may be physically present it doesn't necessarily mean they are engaged. Students are then challenged by the fact that they only see the demonstration once, and then are expected to use the equipment with a certain degree of self-sufficiency.

Today's students are of the YouTube generation, eternally harnessed and connected to their electronic devices. The following graphic shows how frequently Graphic Communications Management students report visiting YouTube.

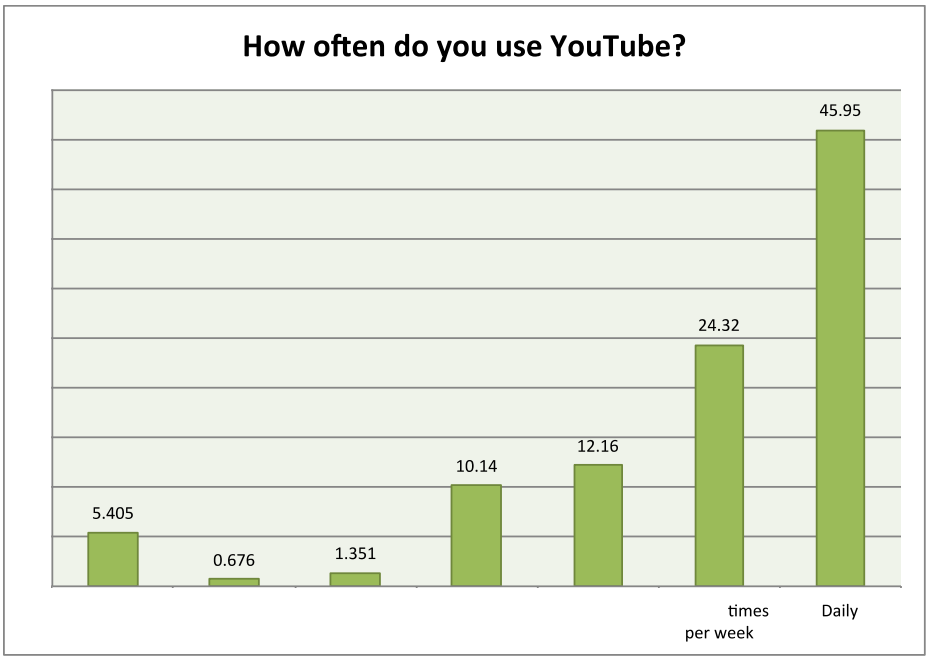

Figure 1 Use of YouTube as reported by the students

Most students in GCM own the portable devices (computers, tablets and smart phones) needed to subscribe to, and interact on a 24/7 basis with digital content like podcasts, short videos, audio, pictures, animations and diagrams. In fact, it can sometimes be a challenge to manage the social use of these devices in a classroom setting. Instead of regarding this technology as an obstacle to teaching and learning, the authors of this paper and one other GCM colleague decided to use this technology in an attempt to enhance student engagement, learning and comprehension by creating a series of short, professional and fun podcasts to enhance and supplement in-class teaching. Specifically, the purpose of the podcasts was to provide students with video demonstrations and instructions on equipment that has historically been a challenge to teach in-class due to large class sizes or the abstract nature of the demonstration. The authors hoped to leverage the intrinsic power of these addictive portable devices, and use them to the students' advantage. As part of this process, the authors created a research methodology to record and analyze the effectiveness of the podcasts at enhancing the student learning experience.

The research question the authors set out to prove was simple: Would the student learning experience be enhanced through the use of podcasts to demonstrate challenging lab demonstrations? Secondary to the primary question, the authors also wanted to determine if the professionalism and quality of the podcasts were factors in their success.

To fund this project, the authors and their colleague submitted a proposal to a newly minted Ryerson funding opportunity, called the Learning and Teaching Enhancement Fund (LTEF). Despite an aggressive number of proposals and limited funding, the "Podlicious" project proposed by the authors and their colleague was awarded one of the largest grants from this fund.

Literature Review

The use of podcasts by post-secondary students is not widespread. Walls et al. (2010) [1] found that only 10% of students downloaded podcasts frequently, while 21% replied not very often and 55% replied that they never downloaded podcasts. A number of studies have previously been undertaken in a range of different post-

secondary disciplines (from management to technology studies) on how podcasts enhance learning and performance. Kay (2012) [2] conducted a review of fifty-three peer-reviewed articles. Some of these studies looked at using podcasts as a revision tool (Dupagne, et al., 2009) [3]. Others looked at the use of podcasts in substitution to existing teaching and yet others studied podcasts used to supplement existing face-to-face teaching (Walls et al. (2010) [1]. Fernandez et al., (2009) [4], concluded that it is the complementing of current content that is effective rather than their replacement.

Podcasts have found to be accessible and allow for multitasking (Fernandez et al., 2009) [4]. Fernandez et al., (2009) [4] found it useful if it is a part of focused learning not just to repeat existing course material but instead to highlight important material. Heilesen et al [5] reported on how podcasts allow for repeated viewing, note taking and reviewing of challenging material, and also reports that this study habit would contribute to increased test scores. The use of podcasts for review was also reported by Lonn et al. [6] Walls et al. [1] commented that students using technology like podcasts could break free of their reliance on the library.

Access to podcasts was studied by Heilesen et al., (2010) [5] and found that students viewed podcasts, not from mobile devices, but from the comfort of their homes where they could concentrate better. Lonn and Teasley (2009) [6] and Sutton-Brady et al., (2009) [7] and Dupagne et al., (2009) [3] also found students viewed podcasts from their home rather than from a portable device. Walls et al., (2010) [1] report how students may view their portable devices are for entertainment and delineate their laptop and home computers as work devices.

Sutton-Brady et al., (2009) [7] reported how students preferred short podcasts due to the time commitment involved, including in the download time required. Taylor et al., (2012) [8] reported that supported podcasts are less than ten minutes in duration. Walls et al. (2010) [1] found that some students did not own or have access to (smart) mobile technology. Kay (2012) [2] found that some students faced technical related to downloading and viewing podcasts while other preferred lectures.

One suggestion Kay (2012) [2] made for a future study was to focus on the quality and design of podcasts. That is a prime objective in the design of the research being presented in this paper. Kay (2012) [2] also found that only 26 of the 53 studies included quantitative measurement and that is another aspect the paper being presented here covers.

Procedures

With the LTEF grant secured, the process of developing the project began. The project involved two parallel workflows to be worked on simultaneously. First, there was the issue of developing the concepts for the podcasts and producing the videos. Second, there was the task of developing and executing the research plan to monitor and record the results of the project.

With the goal of creating high-quality, high-impact podcasts with an edge, the majority of the grant money was allocated to hire two Ryerson students with expertise necessary to technically produce the podcasts. After a formal job posting and interview process, the LTEF team hired one student from Ryerson's Image Arts program, and another student from Ryerson's Radio and Television Arts program. The student from Image Arts was very competent with 3D animation, and the student from Radio and Television Arts was skilled in planning, shooting, and editing video. In addition to their advanced technical skills, these students brought with them a student-learner perspective that helped guide the creation of the videos. The students were routinely asked to provide input on the direction of the project to ensure the videos were well suited to the target audience.

Since the production took place during the summer months (non-teaching semester), everyone worked around summer schedules. Storyboards and scripts were carefully crafted, sound and lighting tested, video and separate sound track recorded. Diagrams, titles and 3D animations were created and added during editing of the podcasts. Versions were made for large screens (desktop and iPad) and for small screens (iPhone), and tested to make sure they were suited for the intended viewing device.

As a delivery method, the authors chose to take advantage of a pilot project that Ryerson's Digital Media Projects Office was engaged in using Apple's iTunesU platform. This seemed to be logical choice for delivery method as GCM uses mostly Apple computers in the labs, iTunes is free for Mac and PC, and the majority of our students own Apple iPhones and iPads. By using iTunesU as the method of delivery, there was no chance that a student would not be able to subscribe to the podcasts. In total, the LTEF team produced a total of 17 podcasts covering topics such as digital photography, CTP devices, press sheet maximization, image size calculations, binding and finishing and sheetfed offset perfecting press operation.

In order to measure the overall effectiveness of the podcasts, the LTEF team decided that they would collect data from the students in two ways. First, an in-class lab demonstration that has been historically challenging from a pedagogical perspective was given to a class. Immediately following this in-class demonstration, the students

were given a quiz to test how much information they retained. Immediately following that class, the students were given access to the podcast that had been created to demonstrate the same concept shown in-class, and encouraged to watch it. In the following class, the students were given the same quiz as they were given before watching the podcast. By analyzing the pre and post podcast results, the team could gauge the overall effectiveness of the podcasts on learning and retention.

Second, the team developed a comprehensive survey for students to complete regarding their experience with the podcast pilot project. The data collected from this survey could be used to gather statistics about students, their behaviour, their use of technology, and overall perception of the podcast project.

To meet Ryerson research ethics requirements, the LTEF team submitted a proposal of their plan to collect data from students to the Ryerson Research Ethics Board. To ensure anonymity of the students, the two quizzes and the survey were administered by teaching assistants. The same teaching assistants collected the data, analyzed it and provided non-associated data. The original copies of the quizzes and surveys were sealed in a box and not provided to the authors for review.

The raw data from the quizzes and the survey was entered into IBM's SPSS V20 software for analysis.

Results

Pre and Post Podcast Quizzes

As mentioned before, the purpose of the pre and post Podcast quizzes was to determine if student learning retention and engagement increased after the podcast was viewed.

While the results of the quizzes were important for measuring outcome, it should be noted that there were a few issues that limited the value of the quizzes. First, student participation in the research project was entirely voluntary. In order to ensure that proper research ethics were adhered to, students had to sign an agreement indicating that they consented to participate. As such, only quizzes completed by students that signed the agreement could be used to generate the raw data tables. This became somewhat confusing as many students that did not sign an agreement wrote the quizzes, and many that signed the agreement did not partake in the quizzes. Further, the participation in the post podcast quiz varied substantially from the pre podcast quiz. For example, there were students that wrote the first quiz but not the second, and vice versa. Also, participation rates for the second quiz were notably lower than the first quiz.

Nevertheless, there were a few conclusions that were derived from the pre and post podcast quizzes. First, there was a marginal improvement in correct responses in most cases after the podcast was watched. Second, it was noted that the improvement in scores was significantly better for some topics than others. For example, the post podcast quiz results for perfecting were markedly improved over the pre podcast quiz; in contrast, the CTP post podcast quiz results actually trended down (sometimes significantly) from the pre podcast quiz. The difference between the pre and post podcast quizzes for binding and finishing showed no significant improvements or downward trends.

Overall, however, analysis of the pre and post podcast quiz results showed a trend of improvement with regards to correct responses. This trend could be viewed as positive with regards to the effectiveness of the podcasts as a learning supplement.

Survey Results

Significant useful information was extracted from the student survey, which had an overall greater participation rate (and therefore larger sample size) than the quizzes. In addition to useful statistical data, there were several interesting trends that were presented which enabled the authors to better understand student perception.

Table 1 Demographics of the survey respondents

Demographics of Podlicious Survey Respondents				
Number of Respondents:	Male Respondents	Female Respondents	Transgendered Respondents	Gender Unidentified
157	37	105	2	13
Age 17-20 Years	Age 21-23 Years	Age > 30 Years	Age: Other	Age Unidentified
107	36	2	4	8
Cumulative GPA A+ to A-	Cumulative GPA B+ to B-	Cumulative GPA C+ to C-	Cumulative GPA Other	Cumulative GPA Unidentified
20	102	11	4	20
Year of study 1st Year	Year of study 2nd Year	Year of study 3rd Year	Year of study 4th Year	Year of study Unidentified
48	71	27	3	8

The authors took advantage of the survey tool to not only get feedback about user experience using the podcasts, but to also get a better sense of who the students were demographically, and what their comfort level and proficiency levels were in regards to technology. The table below demonstrates some interesting demographics about the survey participants.

The survey also provided the authors with some useful information about the types of technology the students own and how they use this technology on a daily basis. As Figure 2 indicates, a significant number of the survey respondents own laptop computers or smart phones.

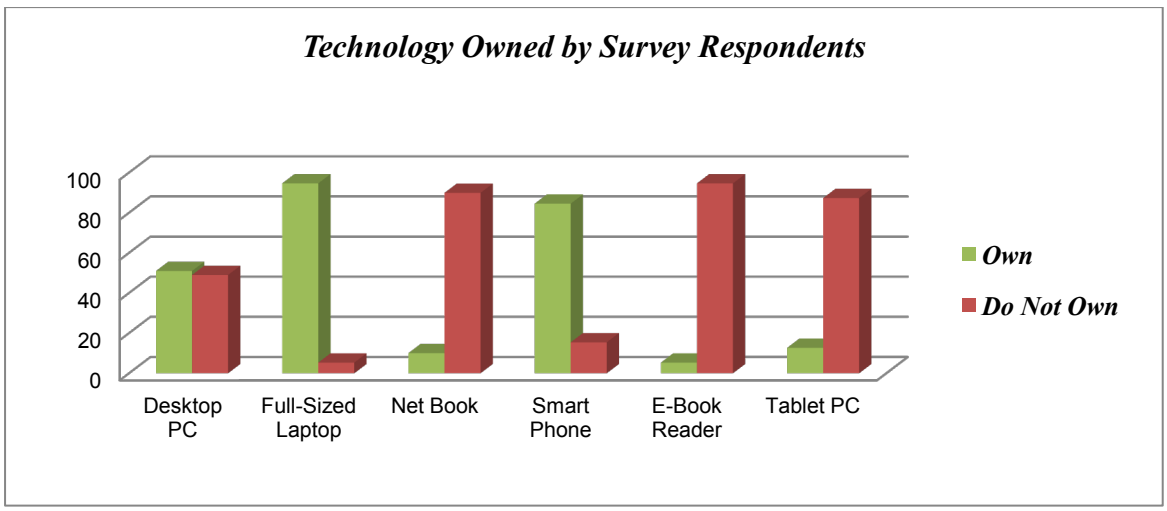

Figure 2 Technology owned by survey respondents

The survey clearly demonstrated that the majority of students watched the podcasts using Apple products. Interesting, a strong majority of students (89%) indicated that they watched the podcasts on an Apple laptop computer; however, only 23% indicated that they watched the podcasts on an iPad or iPhone. This result is in line with Sutton-Brady et al. [1]. In that study 87% of the students listened to the podcasts on their home computers.

The results of the survey also provided the authors with useful data about the perceptions that the students have about podcasts in general as well as valuable feedback on the Podlicious podcasts themselves. The majority of students surveyed agreed or strongly agreed that short duration, good image quality, and good sound quality are important characteristics of an effective podcast. In the study mentioned above [1], students said that they stopped listening to podcasts that were longer than 8 minutes. Another study [2] says that podcasts should not be more than 10 minutes in length. These views coincided with the authors' own perceptions; consequently it was quite validating for the authors when the majority of survey participants agreed or strongly agreed that the GCM Podlicious podcasts had the right length, and good image and sound quality. Table 2 below summarizes the survey questions tailored directly to the Podlicious podcasts.

Table 2 Student feedback on the podicious podcasts

Student Feedback on the Podlicious Podcasts			
	Agree and Strongly Agree (%)	Neiter Agree or Disagree (%)	Disagree and Strongly Disagree (%)
GCM Podlicious Podcast(s) used in this course successfully supplemented what I learned in class	80	18	2
I liked using the GCM Podlicious Podcasts as part of the course material	78	21	1
Thee GCM Podlicious Podcasts were easily accessible for me	67	22	11
GCM Podlicious Podcasts were easily viewed from the technology I already own	81	17	2
There were certain aspects of the live lab demonstrations that I understood better after I watched the related podcasts	72	24	4
The podcasts helped me see equipment close-up in a way I was not able to see it in the live lab demonstration	76	21	3
Being able to review the podcasts once, or more than once after the live demonstration helped me better retain the subject matter	84	15	1
I feel that the combination of the live demo and the podcast have prepared me better for testing on this subject matter versus just having the live demo	82	16	2

Discussion

The GCM Podlicious podcast project was a small pilot project geared towards gathering data on the effectiveness of podcast technology as a tool to enhance (not replace) face-to-face learning opportunities that pose challenges either due to shear number of students or the complexity of the topic, or both. The idea was to harness the technology and skill already possessed by the student to provide video-aided learning to demonstrate complex learning outcomes.

The results of the student survey completed at the end of the pilot clearly demonstrate that the students have the technology and capacity to engage in video-based learning via podcasts delivered through Apple's iTunesU. Similarly, the survey indicates that the students felt that the podcasts were useful, well prepared, and a benefit over face-to-face learning alone. One issue that puzzled the authors was that despite the positive feedback students gave on the survey, the pre and post podcast quizzes administered in-class did not yield substantive evidence that the podcasts actually improved student learning and retention. In many cases, post podcast quizzes resulted in marginalized improvements only; in some instances, the percentage of successful responses to quiz questions actually declined after the podcasts were viewed. A different study [3] showed that the efficacy of podcasts is fairly weak. The study mentioned that students see podcasts as a genuine improvement to the study environment. The same study also said that student's grades only improved through podcasts when they were taking notes while listening to the podcasts. The last statement is also supported by Kay [4].

While the exact cause for these results is unknown, there are some theories worth considering. First, as mentioned earlier, participation for this pilot was voluntary, and in order to conform to the Ryerson's Research Ethics Board requirements, the authors were not able to administer the quizzes. Instead, teaching assistants were recruited for the task. This made it hard for the authors to track participation. For example, there is no way for the authors to verify that the same students that wrote the pre podcast quizzes also wrote the post podcast

quizzes. Further, the overall participation on the quizzes was lower than the survey participation. Second, the number of students that wrote the post podcast quizzes was considerably lower than the number that wrote the pre podcast quizzes. The reduced sample size on the second quiz could have skewed the results.

When creating the podcasts for the Podlicious pilot program, the research team spent a considerable amount of time, effort, and funding into creating professional quality video podcasts. The result was a series of podcasts that were rated well by the students in the pilot. Indeed many commented on the quality of the videos the authors created as being a contributing factor to the success of these videos as learning tools. The downside to this is that it took three months to create seventeen videos, and the average cost to create each video was greater than $700. That is a substantial time and money commitment, especially given that the technologies highlighted in some of these videos change substantially every one to two years. While this can be seen as an investment in learning, it can be quite difficult to find the time and money to maintain such a high level of quality in these podcasts, especially at the School level.

Conclusion

The students at the School of Graphic Communications Management at Ryerson University in Toronto Canada have the technical know-how, experience, tools and expertise to incorporate educational video podcasts into their overall learning strategy. The intent is not to replace regular instruction with podcasts; rather, the podcasts are used to assist in demonstrating equipment and concepts that can be challenging to deliver in a face-to-face environment.

The Podlicious podcast pilot project done through the funding provided by Ryerson's Learning and Teaching Enhancement Fund proved to be successful at engaging and exciting learners by offering them video supplements to in-class topics. While this particular pilot did not yield conclusive evidence that learning and retention improved with the help of the podcasts, it did clearly demonstrate that the students perceived the podcasts to be relevant, useful, and worthwhile.

Based on the conclusions of this project, the authors feel that a more structured research project with a control group should be initiated to further evaluate the effectiveness of the Podlicious podcasts.

Further Considerations

While the Podlicious pilot project yielded valuable data on the experiences of students and their perceptions of podcasts as learning enhancement tools, the project failed to provide conclusive evidence that the podcasts did enhance student learning and retention.

Upon reflection, there are several parts of the research methodology that could be modified for a second trial. First, it would be beneficial if the participants of the trial were not the students of the researchers. One of the challenges with the initial pilot was that the participants were also the active students of the researchers, which meant that the researchers had to ensure student anonymity throughout the process in order to adhere to Ryerson's Research Ethics Board standards and avoid a conflict of interest. This made it difficult to monitor the process as closely as the authors wanted. Also, the trial was built into class time, which limited the flexibility of delivering the material to the students. Another modification that could be made for the second trial is to have both an entrance and exit interview with each participant in order to identify and track his or her progress after the trial. Given that the results of the first trial showed an empirical difference between perception of worth and actual outcomes, it could be very useful to incorporate qualitative data collection strategies into the research methodology to compliment quantitative data collection.

Another consideration would be to devote more time to the ongoing field of the literature available on the topic of podcasting in education. Although the authors did spend considerable time on the literature prior to the pilot, given the nature of podcasting one can appreciate that the literature expanded and changed significantly by the end of the project due to the rapid changes in technology and also in this technology being available to the majority of students.

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Author biography

Art Seto is an Associate Professor at Ryerson University in Toronto Canada. He has been teaching in post-secondary education since 2002 in the areas of management studies, prepress and currently teaches bindery and finishing. He has an MBA in information technology management from Athabasca University in Canada and is currently working towards a PhD. His areas of research are binding and finishing, bookbinding, book arts, and history of the book. He has served on a number of boards of directors in the printing industry and currently sits on the board of directors of the Canadian Bookbinders and Book Arts Guild.

ePUB Test Form

Richard M. Adams II[1], Reem el Asaleh[1], Jessica Augusto[1],
Denis Dorofeev[2], and Yulia Veselskaya[2]

[1]*School of Graphic Communications Management, Ryerson University, Toronto, Canada*
[2]*Institute of Publishing and Printing, National Technical University of Ukraine, Kiev, Ukraine*
richard.adams@ryerson.ca, reem.elasaleh@ryerson.ca, jaugusto@ryerson.ca, denipsys@gmail.com, julia.vecelska@gmail.com,

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Abstract

The ePub format for digital books was designed with variable-format pages that adapt to various sizes and orientations of electronic eBook readers and tablet computers, while maintaining a constant font size that facilitates reading text-heavy documents. Noting that the same ePub document could look different, depending upon the platform and eBook-reader app, the authors designed an EPUB test form, following the philosophy of the ink-and-paper press test forms developed by the Graphic Arts Technical Foundation (GATF, now Printing Industries of America, PIA). The form includes multiple character, paragraph, table, color, image, and multimedia elements that can be used to assess the appearance and function of these elements on eBook readers and apps.

Introduction

What is the EPUB Format?
The main advantages of publishing digital books, or eBooks, in the EPUB format are its ability to reflow text to different sizes and orientations of eBook readers and tablet computers, while maintaining a constant, easy-to-read text size. At the same time, designing reflowable pages can be difficult to get used to for anyone who is used to designing for traditional ink-on-paper media, with fixed page sizes.

Why a Test Form?
Noting that the flow of text and graphics can be hard to visualize and that some formatting specifications are honored while others are ignored by various eBook readers and apps, the authors got the idea to design a test form for EPUBs modeled on the same idea as the ink-and-paper test forms developed by the Graphic Arts Technical Foundation (GATF, now the Printing Industries of America, PIA). [1]

What is in the Form?
The EPUB Test Form is an electronic document in .ePub format. The authors included samples of various text, graphic and multimedia objects that could be used to test display capabilities and rendition of eBook readers, tablet computers, and apps. It is divided into eight chapters, which are explained in further detail in this paper:
• Chapter 1, Introduction—Describes the test form, its purpose and contents.
• Chapter 2, Text—Includes samples of various fonts and font styles, including specifications that can be applied to a single letter, word, or phrase.
• Chapter 3, Paragraphs—Includes examples of various paragraph formats and styles applicable to paragraphs, as delimited by the paragraph mark (¶).
• Chapter 4, Color—Includes a sample web-safe color palette that can be measured with an emissive spectrophotometer or colorimeter.
• Chapter 5, Images—Includes samples of various images and style specifications that can be applied to them.
• Chapter 6, Tables—Includes examples of tables and the formatting that can be applied to tables.
• Chapter 7, Links—Includes local links within the document and global links to the World Wide Web.
• Chapter 8, Media Layers for Audio/Video—Includes samples of several media objects and options for playing them.

How to Use the Test Form
Once downloaded, the EPUB Test Form document can be loaded onto and displayed on any eBook reader or tablet computer and read with any app that supports the ePub format. File-transfer applications that may be helpful for this purpose include Dropbox (www.dropbox.com) and Google Drive (drive.google.com). These programs include both a Mac/Win program and iOS/Android apps for transferring files.

Ideas for Future Research
The goal of this paper was to create and describe an EPUB Test Form. Similar to the GATF press test forms that underwent progressive iterations with user feedback, the authors consider the test form a "work-in-progress" that can benefit from user feedback and suggestions. Users are welcome to contact any of the authors with suggestions and ideas.

In future work the authors plan to test the test form with a variety of eBook readers, tablets, and apps. Another goal is to create a checklist of what to look for when interpreting the test form on a specific platform.

eBooks and the EPUB Format

An eBook is an electronic version of a book that can be read on almost every digital device, including tablet computers, desktop and laptop PCs, and mobile devices. Recent technical developments in eReaders, eBook formats and the introductions of iPads in 2010 have contributed to the enhancement and spread of eBooks.

In terms of eBook formats, there are currently different formats that have been using by many publishers to create eBooks including PDF format. Some of these formats are supported by specific eReaders such as AZW and KF8 formats that are supported by widely spread Amazon's Kindle. EPUB, on the other hand, is the most common adopted format by many others eReaders except Amazon's Kindle. The introduction of the first version of EPUB was by the International Digital Publishing Forum (IDPF) in 2007. EPUB 3.0 is the latest standardized specification that was approved by IDPF in 2011. [2]

EPUB is a web standard and Extensible Markup Language (XML) based format that gain reputations due its capability of reflowing text for different display sizes of different eReaders without effecting the text size as oppose to a PDF file format [3]. Basically, the EPUB context documents are defined by eXtended HyperText Markup Language (XHTML) and Scalable Victor Graphics (SVG) and formatted by Cascading Style Sheet (.css). Web pages use similar definition, as XHTLM is a special version of HyperText Markup Language (HTML) code, which is used to define a web page.

Moreover, the components of an EPUB publication based on the latest IDPF standards are categorized under four major specifications: EPUB Publications 3.0, EPUB Content Documents 3.0, EPUB Open Container Format (OCF) 3.0 and EPUB Media Overlays 3.0. According to IDPF *"these new specifications significantly increase the format's capabilities in order to better support a wider range of publication requirements, including complex layouts, rich media and interactivity, and global typography features."* [2]

Adobe InDesign, QuarkXPress or Microsoft Word software can be used to create an EPUB document. Some considerations need to be addressed when designing publication documents that consist of text and graphics. In case of InDesign, which is the common used application to generate EPUBs and fixed-size PDF documents, a feature like Master page is important for PDF documents but is less practical for a variable-size EPUB. Master page is responsible for holding repeating elements such as headlines or page numbers that will appear in the whole document at the same fixed position. EPUB is characterized by its flowable format, and thus Master pages are not used with EPUB [4]. The aim of this paper is to evaluate a designed EPUB "test form" document in InDesign that contains several elements such as table, links text and graphics among different eReaders and eBook apps.

Contents of the EPUB Test Form

Chapter 1—Introduction

This chapter explains the purpose of the EPUB Test Form and describes its contents.

Chapter 2—Text

A character represents anything typed and can vary from a letter, number, punctuation mark, symbol to even a space [5]. Characters when combined together create the words, sentences and paragraphs of electronic documents. Some basic character modifications that can be applied to text in EPUBs include bolding, italicizing, underlining and changing the font size and colour of text. Converting text to small capitals and all capitals can also be applied to text in EPUBs.

EPUBs do not have the same capabilities as other programs when it comes to using fonts as they only support OpenType and some TrueType fonts. Additionally EPUB readers enable users to alter the font size and font of the text within the EPUB. It is therefore recommended to use a basic font and font size when creating an EPUB for greatest compatibility amongst all EPUB readers [6]. Fonts that are not considered default for EPUBs can be added to documents by embedding them. The font can be embedded into the EPUB using a CSS style sheet and coding to inform the EPUB which font will be used within the document [7]:

```
@font-face{
        font-family:
        font-weight:
        font-style:
        src:
}
```

Another code is then written to tell where in the EPUB the font will be used. For example a font that will be applied to the main title of the document will use the coding [7]:

```
h1 {font-family
}
```

It is important to note however that licensing and increased file size may become issues when embedding fonts.
EPUBs do not support ordinal numbers (ordered numbers) when created from Adobe InDesign. They however can be created with HTML coding. The ordinal number, 1, as all other ordinal numbers, can be formatted using this code [8]:

```
1<sup>st</sup>
```

Fractions that are applied in Adobe InDesign using the Glyphs feature under Type do maintain their integrity in EPUBs. If the fraction is uncommon and not available in the Glyphs panel this coding can be used to create custom fractions [8]:

```
<sup>1</sup>&frasl;<sub>4</sub>
```

Chapter 3—Paragraphs

Chapter 3 shows formatting attributes that can be assigned to a paragraph in Adobe InDesign CS6.
Paragraph attributes apply to all lines of a paragraph, which is delimited by a carriage return character (¶). Paragraph settings cannot be applied to a single character or group of characters, which may instead be defined by character styles.
In InDesign, a character style setting takes priority over the same setting in a paragraph style. That is, if conflicting settings are simultaneously applied in a paragraph and character style, those in the character style will take precedence.
Each paragraph of this chapter in the test form has example of several attributes of each item of paragraph formatting.
Attributes include:

- horizontal alignment (left, center, right, justified)
- vertical alignment (top, center, bottom, justify)
- indent (left, right, first line left, last line right)
- space before and space after paragraph
- glyph scaling (%)
- word spacing (%)
- letter spacing (%)
- rules (above/below, weight, color)
- drop caps

Chapter 4—Color

Many eBook readers can display color, while others are black-and-white. For color displays, the quality of colors basically depends on the eReader device that is used to read a colorful EPUB file. The most affordable eReaders are monochrome devices such as Amazon's Kindle Paper-White, Sony's Pocket Reader, Barnes & Noble's Nook Simple Touch, and Kobo's Aura HD. However, developers have recently introduced new versions of eReaders that fully support colors. In addition, some users prefer to read their eBooks on their tablet PCs while browsing the Web or playing video games at the same time.
The advantages of monochromatic eReaders are low cost and minimal power consumption. Sony eReaders were the first to use E-Ink technology. E-Ink uses encapsulated white and black charged particles that adhere to the display surface based on the applied charge, only consuming power when the displayed image is altered. This

technology allows for lightweight devices with a wide viewing angle that dose not require a backlight and mimics the reading experience of a printed book. Displays with similar technology include those from Kindle, Nook and Kobo devices. [9]

In 2009 Barnes & Noble announced their Nook 1st edition eReader, which featured a separate color LCD touchscreen located below its 6-inch monochrome E-Ink display and that was used mainly for navigation [10]. This started the revolution toward color-capable eReaders.

In 2010, E-Ink introduced their Triton Imaging Film technology, which maintains the same advantages of their monochrome displays but with the ability of displaying 4096 colors [11]. Hanvon's WISEreader C920 is the first eReader that is equipped with this technology. It was released in 2011 in China only [12]. On the other hand, Hanvon C18 and Kyobo eReaders, which available in Asia, are equipped with Mirasol's color display technology that was introduced by Qualcomm in 2011 [13]. Both the E-Ink and Qualcomm competitive color technologies offer similar advantages of longer battery life and comfortable reading experience in bright sunlight. However, while E-Ink provides wider viewing angle, Qualcomm's Mirasol technology provides more saturated colors with higher refresh rates to display videos [14].

While the aforementioned color eReaders are only available in Asia, other monochrome eReader manufacturers have adapted LCD display technology with LED backlit, similar to tablet PCs, that can display rich colors include the Amazon Kindle Fire, Barnes & Noble Nook HD+, and Kobo Arc. In addition, the new IPS Panel (In-Plane Switching technology) technology makes displayed colors more consistent from all viewing angles. IPS technology has been used with almost all Android tables and iPads along with the Amazon Kindle Fire and Barnes & Noble Nook HD+. On their Galaxy, Samsung employed their Super PLS (Plane-to-Line Switching) technology, which has enhanced performance over the common IPS technology in terms of viewing angles, brightness, and image quality. [15]

Despite the common fact of having a display device with the richest displayed colors will enhance the reading experiences for readers, it is also important to achieve a consistent appearance of that displayed color across different reading devices. While this seems less important of some readers, this feature is for others. For instance, if an artist or a photographer would like to create EPUB files about his/her work and would like to include some pictures of his/her work, how does he/she know those readers will see it accurately?
And thus, the "Color" chapter of the EPUB test form includes a color test target that consists of some web-safe color patches to check color appearance across different eReaders and tablet devices with different eBook Apps.

Chapter 5—Images

The EPUB file format supports the following image file formats:

- GIF
- JPG
- PNG
- SVG

Also, it is possible to include non-core formats such as Flash. In this case you have to provide a fallback file which will be presented to user with reader system that doesn't support above mentioned non-core format.
Images are included into EPUB files by standard HTML means. Also the mention of image file in content.opf is obligatory.

No external DTD should be declared in DOCTYPE section of SVG file. Applications such as Adobe Illustrator are including external DTD files, which lead to EPUB 3.0 compliance validation error. So, the DOCTYPE section in SVG files should be deleted as it is already declared in SVG format specification.
The inclusion of images in HTML 5 Canvas element is also possible while fallback image or text is provided. Canvas objects are filled with JavaScript. So the reading system has to support this technology. To allow JavaScript in EPUB file add "scripted" property into declaration of page in content.opf file.

Chapter 6—Tables

Tables in HTML are useful for organizing data and can also be used for positioning text and graphics on the page. Table tags include the table itself <table>, rows <tr>, cells <td>, header <th>, and caption <caption>. Cells may also be combined with the column span <colspan> and row span <rowspan> tags.

Styles that can be applied to tables include cell-spacing, cell-padding, margin (including margin in general, margin-left, margin-right, margin-top, and margin-bottom), bgcolor, and border.
Code for a 2-column, 2-row table would look as follows:

```
<table>
        <tr> <!-- row 1 -->
                <td></td> <!-- column 1-->
                <td></td> <!-- column 2-->
        </tr>
        <tr> <!-- row 1 -->
                <td></td> <!-- column 1-->
                <td></td> <!-- column 2-->
        </tr>
</table>
```

The “Tables” chapter of the EPUB test form includes several tables to check for positioning, background colors, borders, and padding.

Chapter 7—Links

Standard HTML5 linking
Among the additions that EPUB 3.0 has added is a new flexible method of linking inside a document. EPUB 3.0 has two methods of linking, the standard HTML5 and the new method called CFI (Canonical Fragment Identifier), which describes and unifies the functionality related to the linking inside and outside of document.

Linking inside and outside of EPUB container
An EPUB CFI can be used to reference content inside the container. This kind of referencing can be achieved by specifying a reference to the Package Document followed by a CFI, which must be resolved starting from the root package element. The support for CFI linking is still not supported by the most of the readers. The format is bit complicated but offers much more functionality than standard HTML5 linking. For example, you can make a link to a specific part of audio/video clip or to some region of the image.

The format looks like this:

content.opf#EPUBcfi(/6/6[EPUBTestForm-7-2]!/4[EPUBTestForm-7-2]/8[par2]/1:30) Which means the link inside the publication (intra-publication link) that refers to the 3rd element in Spine tag of OPF file, 3rd element inside of the object defined in Spine tag (with id EPUBTestForm-7-2, 2nd element (body) of that file, 8th element inside the body tag (paragraph with id 'par2'), the first unnamed element inside that tag (the text string) and the offset containing 30 characters. That leads to the word (here) in EPUBTestForm-7-2.xhtml file. To make a reference to another EPUB file, place it name instead of content.opf prefix. In case of seconds into an audio or video, the final number should be preceded by a tilde (~) for example: ~2.5 would mean second 2.5 inside an audio or video element. This really shows the strength of CFI. CFI can also reference part of an image. For example @50:50 would mean the center of an image.

Chapter 8—Multimedia

Multimedia in the EPUB 3.0 specification does support embedding of audio and video information. Nevertheless there are several ways of including multimedia, such as using the native HTML5 <audio> and <video> elements, Media Overlays functionality, and insertion of non-core content types.
The IDPF specification does not define any video codecs as Core Media Types. But there is a note about video types recommendations: "It is recommended that Reading Systems support at least one of the [H.264] and [VP8] video codecs, but this is not a conformance requirement; a Reading System may support no video codecs at all". Here we present a table of supported formats.

Media Type	Extension	Comment
video/webm	.webm	Specification allows the lack of support of video formats. Still, most readers which are using Webkit engine do support this format.
video/mp4	.mp4	Specification allows the lack of support of video formats. Still, most readers which are using Gecko/Webkit engines do support this format.
audio/mpeg	.mp3	MP3 audio.
audio/mp4	.mp4	AAC LC audio using MP4 container.

In fact most of the readers do support embedding of other video and audio formats such as m4v, mov, ogg etc. But above mentioned formats are the only recommended for conformance to EPUB 3.0 standard.
Test of standard HTML5 video embedding (H.264) function with controls.

: To include such type of a video, you need to use the standard HTML5+XHTML <video> element. Also, you need to reference the file in content.opf file.

Test of standard HTML5 video embedding function with autoplay: Autoplay functionality is useful in EPUB files when you need to play the video right after the page is shown to the user. Still, the specification says: "All referenced audio and video media embedded within an EPUB Content Document must be initialized to their "stopped" state, and be ready to be played from the zero-position within their content stream (possibly displaying the image specified using the HTML5 poster attribute). This requirement overrides the default behavior defined by the HTML5 autoplay attribute". So, the autoplay attribute can should be ignored in EPUB complied readers, but the official IDPF reader Readium do not ignore it, and we think that this attribute is useful when used wisely. So, we included this test into Test Form. To allow video to automatically start, add the autoplay="autoplay" attribute to <video> tag.

SWF (Flash) format video: To include non-core media types such as FLASH files (.swf) (which are supported by number of readers) there is an option with including of the desired file with mentioning a fallback file which should be placed in case if the reader cannot play this file. Fallbacks are provided using the fallback attribute on the manifest item element that represents the Publication Resource. The fallback attribute's IDREF value must resolve to another item in the manifest. This fallback item may itself specify another fallback item, and so on.

The insertion of custom controls is possible with HTML5 means. The trigger element enables the creation of markup-defined user interfaces for controlling multimedia objects, such as audio and video playback, in both scripted and non-scripted contexts. The trigger element associates an event from a specified source object (observer) with a desired action to be performed with a specified target object (ref). Systems that support video or audio playback must support the EPUB:trigger element.

The inclusion of remote resources in an EPUB publication is indicated via the remote-resources property on the manifest item element in content.opf file. Remember to include both video formats to achieve maximum compatibility.

Test of audio overlay feature: Audio overlay functionality allows to add audio narration to the text. To add audio overlay, you have to create a SMIL file (an XML format designed for applying overlays).

To turn on audio, look for the corresponding button in the reader interface. Books featuring synchronized audio narration are found in mainstream e-books, educational tools and e-books formatted for persons with print disabilities. In EPUB 3.0, these types of books are created by using Media Overlay Documents to describe the timing for the pre-recorded audio narration and how it relates to the EPUB Content Document markup. The file format for Media Overlays is defined as a subset of SMIL, a W3C recommendation for representing synchronized multimedia information in XML. The Media Overlays feature is designed to be transparent to EPUB Reading Systems that do not support the feature. The inclusion of Media Overlays in an EPUB Publication has no impact on the ability of Media Overlay-unaware Reading Systems to render that Publication as a "regular" EPUB Publication. Although future versions of this specification may incorporate support for video media (e.g., synchronized text/sign-language books), this version supports only synchronizing audio media with the EPUB Content Document.

Adding multimedia in EPUB with InDesign: The process of including of multimedia in InDesign document is simple. Just place a video or audio on your document via File-Place dialog and then export it to EPUB 3.0 format. You can also choose a poster for your video in InDesign's Media window (shown in the red ellipse on

the figure below). Still, if you want to embed non-core format video such as Flash video or to add Media Overlay (audio narration) you'll have to edit the EPUB file directly.

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Author biography

Richard Adams, Ph.D., is Associate Professor at Ryerson University's School of Graphic Communications Management. He specializes in electronic documents, web design, and color management.
Prior to joining Ryerson, Rich was a technical specialist at the training division of X-Rite, Inc., which specialized in color management and large-format inkjet printing. Previously, as a research scientist at the Printing Industries of America, Rich authored or co-authored some 15 titles.
Rich received a Master's Degree in Printing Technology from Rochester Institute of Technology. He also completed the Ryerson Chang School's Certificate in Web Design. He also completed a Ph.D. at Cornell University.
Rich's areas of expertise include colour management, digital photography, electronic document design, web design, and quality control in lithographic printing. He is a coauthor of "The GATF Practical Guide to Color Management," "Digital Photography for Print," and "Introduction to Security Printing," all from PIA Press.

Mobile Computing in Higher Education Teaching - Trends and Methods

Mathias Hinkelmann[1], Sebastian Kelle[2]
[1]*Prof. Dr. Mathias Hinkelmann, Vice-President, Stuttgart Media University, Germany*
[2]*Dr. Sebastian Kelle, Diaktikzentrum, Stuttgart Media University, Germany*
hinkelmann@hdm-stuttgart.de, kelle@hdm-stuttgart.de

Keywords: Mobile Computing, Teaching Technology

Abstract

The use of mobile computers in higher education has been commonplace on a large scale since the beginning of the current millennium. In Germany, an initiative called "Notebook University" has successfully promoted and supported the availability of laptop computers for students [3]. For many lecturer laptop computers are essential. Laptops are used to communicate with the students and lectures are given as computer presentation. Looking back how lectures were held in the past it can be observed that lectures held with blackboard or overhead projector (OHP) provide more possibilities of interaction between lecturer and students than lectures that are only computer presentations.
The use of laptop computers increased until 2010, when a sudden diversification in market penetration of mobile devices changed the situation. Powerful mobile computers with touch-screens became popular. In 2012 the number of sold mobile computers with touch-screens superseded the sales numbers of standard laptop computers [1]. Practical experiences with these devices in lectures show that migrating to computers that enable pen entered input takes advantage of traditional teaching tools like blackboard and overhead projector and computers and therefore can be used to regain interactivity options. At Stuttgart Media University touch-screen devices have been used in the context of "interactive lecture" method [2] since 2004 and teaching methods are derived

- electronic blackboard (eBlackboard) environments are taking the benefit of touch-screen devices to enhance the interactivity between lecturer and audience and
- cloze enhances eBlackboards by using incomplete presentation content that gets manually completed during the discourse between lecturer and audience.

From a technical point of view, we can differentiate between the following classes of devices:

- Tablet-PC: A laptop with standard operating systems and software that is equipped with a touch-screen. These devices are available since at least 10 years but had only a small market share.
- Tablet or Pad: These devices are derived from smartphones and are available since 2010. Therefore they have mobile operating systems, which also are commonly used in smartphones. These devices do not run standard desktop software, but rather lightweight mobile applications, also known as "apps".

Therefore it is necessary to have a close look to the differences in terms of usability and software available between types of tablets to set up an eBlackboard environment.

Development of Educational Media

Since hundreds of years, blackboards are used in teaching. Johan Comenius' book "Orbis sensualium pictus" (1653) contains a drawing of a classroom equipped with a blackboard. On blackboards the content is generated during the lecture. An interactive discourse between lecturer and audience can be used to make complex issues easier to understand and ad hoc explanations can be illustrated during the lecture. These advantages of blackboards are making them even today essential in every classroom and they are still the preferred tool for some lecturer.
But there are some drawbacks of blackboards. Firstly, complex sketches are difficult and time consuming to draw. Therefore in former times maps are used in addition to the blackboard. Maps are the first kind of ready-made content for presentations. Secondly, blackboards have a limited space and do not provide a rewind function. If the blackboard is full, the text or sketch has to be wiped out. It is gone and has to be rewritten if it is needed again. Thirdly, the teacher tends to talk to the blackboard and is not facing the audience.
In the late 20's of the 20th century the overhead projector (OHP) was invented. It became popular in the 60's. Which possibilities arose from the usage of an OHP?
With OHP nearly all disadvantages of blackboards can be addressed. Keeping written slides a rewind to topics that are addressed even some lessons ago is possible. Having slides prepared with sketches or having photocopied figures, maps are to longer necessary. The teacher is able to face the audience all the time. In addition to the addressed drawbacks of blackboards the OHP enables a new educational method. Difficult circumstances can be explained by combining prepared content (sketch or photocopy) and handwritten annotations.

In the early years prepared slides were either hand written or produced using type writer and photocopy. In the 80's computers were used to produce slides with an improved quality. In most cases the quality improvement concerned layout issues. Didactical issues are not always addressed. But using computers and dedicated software to produce slides leads to an increased number of slides per presentation.
By the late 90's data projectors became more and more available and OHP-slides became obsolete. Computers are used to produce and present the slides. Slides are animated and mixed with multimedia content. But looking to the result it is obvious that all this technical support is mainly focused on the lecturer. Benefits for the audience are not automatically given. Presentations are often nothing more than just a show. Sometimes presentation became more like "Power Point Karaoke" – reading text given on slides. Animations are predefined; ideas or concepts are not developed in an interactive discourse between lecturer and students. These disadvantages are the reason why some lecturers still prefer blackboards or OHP. But the number of classrooms equipped with OHP declines and it is just a question of time that they are gone.

New Options when Using Tablet Computing

In the last 3 years the usage of computers has been changed. Graphical user interfaces are no longer only handled with a pointing device like mouse, touchpad or trackball. Touch-screens are offering a new kind of user interaction directly on the display. Mobile computers equipped with a touch-screen today are called tablet. In combination with software that records the moves on the screen the computer turns into electronic paper (ePaper). With ePaper it is very easy to store and share generated content (handwritten text and sketches). From ePaper it seems to be only a small step to an electronic blackboard (eBlackboard) that reopens didactical options that seemed to be lost.

eBlackboard

Unfortunately turning a tablet into an eBlackboard is more than just connecting the tablet to a data projector and cloning the display content therefore it is useful to consider of some technical aspects of these new devices.
There are two kinds of touch-screens. Inductive or capacitive reacting displays. While using inductive reacting displays a special pen is always required, capacitive reacting displays are focused to be handled with one or more finger. But capacitive reacting displays can also be handled with a special pen. From teaching point of view inductive displays are easier to handle. The user interaction is limited to moves of the pen. Touching the display does not activate any function.
From a technical point of view, we can differentiate between the following classes of devices:

- Tablet-PC: A laptop with standard operating systems and software that is equipped with a touch-screen. The size of the screen is between 12" and 14". These devices are available since at least 10 years but had only a small market share.
- Tablet or Pad: These devices are derived from smartphones and are available since 2010. Therefore they have mobile operating systems, which also are commonly used in smartphones. These devices do not run standard desktop software, but rather lightweight mobile applications, also known as “apps”. The screen size of these devices is between 7" and 10".

Setting up an eBlackboard means to serve two different needs. The lecturer needs to have access to menus whereas the audience "only" wants to perceive the content. The scale of the handwritten text or the sketches also has to fit to the different needs of lecturer and audience. The content presented to the audience has to be stable as zooming of the displayed content causes a loss of attention. Therefore the size of the touch-screen is determining how detailed the scaling issue has to be addressed. Beneath the scaling issue, the display type (inductive or capacitive reaction) has to be addressed. This leads to consider the specific combination of hard- and software. Experiences with tablet computing to set up an eBlackboard can be summarized as follows.
Having a tablet-PC with a 14" inductive reacting touch-screen, scaling is nearly negligible. Best visibility for the audience and most convenient handwriting is given, if the page format is portrait and zoom is "page width". But even the landscape page format can be used if the lecturer takes care for a neat handwriting. Using 12" inductive reacting touch-screen and landscape page format the eBlackboard is no longer convenient for the audience. If the tablet-pc is equipped with a capacitive touch-screen the lecturer has to take care that the screen is only touched with the pen.
The size of the touchscreen of tablets varies from 7" to 10". On devices having 10" or less a special input area as shown in figure 1 is necessary. If this input area is scalable the lecturer does not have to pay attention to the size of his written text. But compared to 12" or 14" touchscreens using smaller screens with an input area is more complex, because positioning the input area is an additional task and working with the input area needs some training. Tests using 8" tablets showed that this should be the minimum touchscreen size. A smaller size can be used for a short presentation but are not appropriate to give a lecture. The need for an input area reduces the drawbacks of capacitive reacting displays, because the input area is defined and limited.

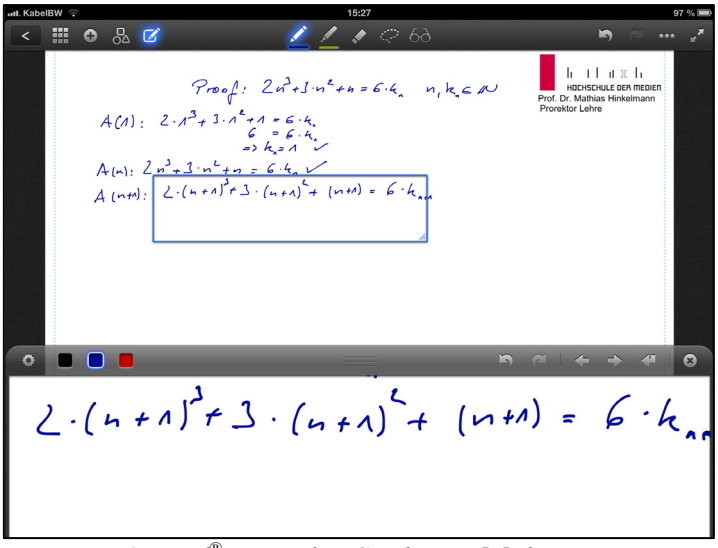

Figure 1. IPad® screenshot GoodNotes [4], lecturers view

Figure 1 shows an IPad® screenshot using the IPad® App "GoodNotes" [4]. "GoodNotes" is designed to take notes either from scratch or into existing files. Files of different format can be imported into the app and re-exported in PDF® documents. The figure shows the lecturers view. On the external screen only the content is displayed. All tool menus and the input area - that can be scaled - are only visible to the lecturer. GoodNotes is an example for a note taking app that addresses the needs of lecturer and audience.

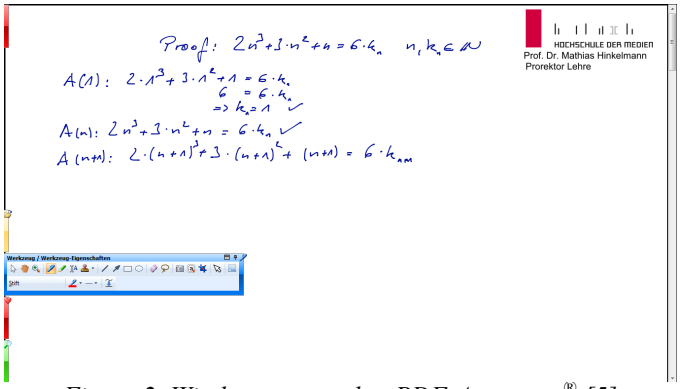

Figure 2. Windows screenshot PDF-Annotator® [5]

Figure 2 is a screenshot of a 13" Windows-based tablet with an inductive reacting touch-screen using the application PDF-Annotator® [5]. In full screen mode all menus are only visible with mouse over. Text and sketches can be entered directly on the page.
Using tablet computing other drawbacks of a blackboard are addressed too. A new page is just a click and after storing rewind to topics that were discussed lessons ago is possible and the lecturer is still able to face the audience.

Cloze derived from Textbooks or Lecture Notes

Using the eBlackboard environment a revival of didactical scenarios is possible, if the base is not blank ePaper but prepared text and sketches from textbooks or lecture notes, the prepared content can be annotated. The annotations can be used to fill in text that was omitted. In other words the base content is a cloze.
The didactical concept of a cloze is not a new one. Some lecturer already used cloze on OHP. But creating a cloze for an OHP can take a large amount of work and is – due to the number of slides - not easy to handle during the session. Nevertheless the combination of full text and omitted text provides a really interesting didactical concept.
The omitted text offers the possibility to interact with the audience. This interaction can be placed in all situations that need e.g.

- a discussion of pros and cons or
- a stepwise development of an idea or
- a calculation.

To derive a cloze any office tool can be used. The process can be split into three steps

1. Write a full text
2. For each part of the text, that will be omitted
    a. mark text and
    b. assign it to special layout tags (hint: use different font color)
3. Generate the cloze
    a. switch font color of layout tags assigned in step 2 to white
    b. generate a PDF document (hint: deactivate security option "copy of text …")

The generated PDF document is used by the students and the lecturer. Compared to OHP no additional work has to be done when using cloze in a tablet computing environment.

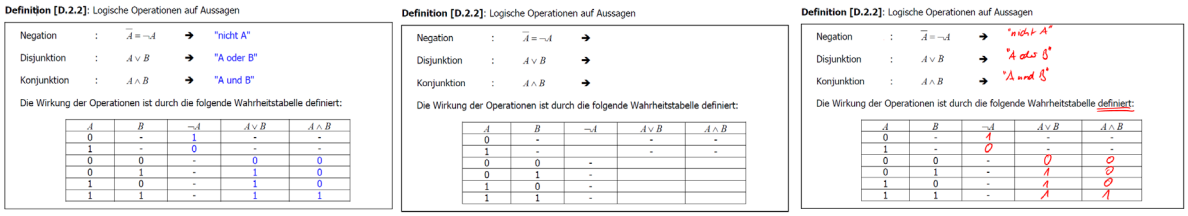

Figure 3. Sample of a cloze used in a lecture

The figure shows the three main steps of a cloze in a lecture.

1. Full text: All text elements that will be omitted have font color blue. A printed version of this text can be used by the lecturer during his talk.
2. Cloze: Document provided to the students and presented by the lecturer
3. Final Document: Text and remarks added.

Due to the fact that the eBlackboard environment is used no additional software is necessary. Another advantage is that a new page can be inserted at any time during the talk if additional explanation is necessary to answer a question of a student.

Conclusion

Tablet computers provide new options in teaching. With the eBlackboard approach tablets provide OHP and computer presentation capabilities. Setting up an eBlackboard needs a consideration of hard- and software components but proven configurations are available. Deriving cloze from textbooks or lecture notes offers more options to interact with the students than giving a simple computer based presentation. At Stuttgart Media Universitiy tablet computing is used since spring 2004 in different lectures of the bachelor study program Computer Sience and Media. Due to the good feedback of the students the number of lectures based on tablet computing is now growing in other study programs as well.

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Author biography

*Prof. Dr. Mathias Hinkelmann (*1965) studied mechanical engineering (1985-1990) and worked at the institute for nuclear engineering and energy systems (1990-1997) at Stuttgart University. He achieved Ph.D. in 2001. From 1997 - 2003 he worked as system consultant and team manager for different consulting companies. In March 2003 he was appointed as professor for database systems and IT project management at Stuttgart Media University. Since January 2007 he is Vicepresident of Stuttgart Media University.*

Teaching Design and Analysis of Experiments for Printing and Packaging Technology

Frank Roch

Faculty of Media, Leipzig University of Applied Sciences, Germany
(HTWK Leipzig) e-mail: roch@fbm.htwk-leipzig.de

Keywords: Experiments, Measurement Uncertainties, Significance

Abstract

"Design of Experiments" (DoE) is implemented more and more in the development of technologies with the aim of strategic quality assurance of products in the last about three decades. Although suitable software is available the potential is still insufficient used in the printing and packaging technology. In practical applications measured results partly processed not critically enough with the result of wrong conclusions and idle power in the elimination of production non-conformances.

In the industrial practice the technical response of interest depends generally not only on one input quantity but will be influenced by a number of interacting factors. With the traditional method „One-Factor-at-a-Time" (OFT) for the investigation of relationships the results are valid only under the special conditions used. But the findings could be totally different in the case of varied constellations of values of other potential input quantities. To unregard this fact will dramatically cause wrong decisions.

Researchers should attach more importance to the statistical analysis of measured results to prove the significance of calculated effects from experimental data. Thereby the application of the methods of DoE can be helpful. It is shown that the use of factorial designs with DoE will truncate the confidence intervals of the effects at the same time with the decrease of the necessary number of experiments.

You will find the one or other chapter about DoE in text books and hand books on Quality Management and Six Sigma. But these treatises are commonly such shortly that more basic knowledge is necessary for better implementation to practical applications. From these reasons DoE should be a compulsory part of the education of engineers, at universities of applied sciences or university colleges at least in master's courses.

The paper wants to give a short outline about a module DoE for students in courses of printing and packaging technology.

Introduction

Research and development in the field of technology suits the purpose to improve the efficiency of production processes and to assure the quality of products. One of the most important means is the experiment. There are requirements to measure many quantities for of pre-print, different printing processes as well as for post-print and packaging technology. In various laboratories the students learn to handle manifold measurement equipment. Nevertheless, universities never will be able to train students for all special tasks they later will have to deal with in the industry. The students should be prepared for life-long learning. That's why we have to offer an education of methodology instead of covering too many special contents.

The success of the effort of research does not mainly depend on the instrumentation available and used, but moreover on an appropriate planning of experiments and, most of all, on a skilled analysis and appraisal of the experimental results. For this reason it isn't important that students learn to press which button for starting the measurement with this or another instrument and to read the display. But it is necessary to evaluate the data statistically and to exploit the results critically in the interpretation of the conclusions.

There are always problems of decision whether a found effect is really significant. Experimenters in many cases

- on the one hand **overlook** effects, that means to ignore them
  (because of measurement uncertainties or too less replicates of realisation),
- on the other hand **construe** effects although they don't exist truly, that means to read tea leaves
  (because of senseless precision assumed and missing correct statistical calculations).

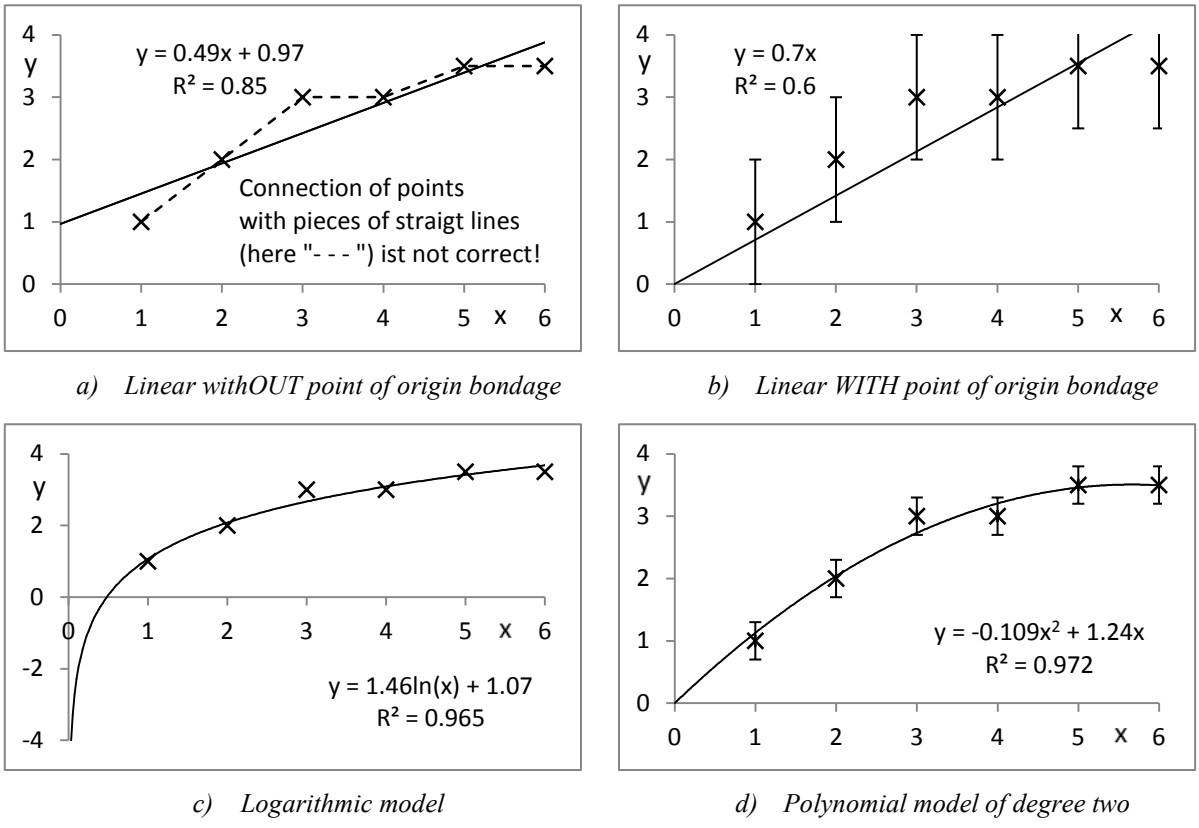
More dangerous than the first fault is even the second mistake, because sometimes a huge struggle will be arranged for abolishment of effect sources, but done for nothing!

This treatise should give some suggestions to avoid wrong implications from experimental results and to teach scientific methods in **measurement technology** for purposes in printing and packaging.

The headline of this paper is …**Design of Experiments**… (abbreviation DoE), this includes to establish constructive plans for experimentation but also to analyse the measured values. But let's to start with some simple basics which are essential not only for DoE, but also in conventional approach.

Experimental Results with Measurement Uncertainties

Let's assume we have measured values of a quantity y depending on one variable x. Of course, always there are uncertainties coming from disturbance, shortly called measuring errors. The same more or less scattering points $(x;\ y)$ are clearly marked in all four parts of *Figure 1*. For the purpose of visualisation the relationship between x and y it would not be correct to connect the single points with pieces of straight lines because it is sure that the true values will not be located just onto those. In fact we have to choose a best-fit curve which does represent the experimental function y=y(x) mathematically.



a) Linear withOUT point of origin bondage

b) Linear WITH point of origin bondage

c) Logarithmic model

d) Polynomial model of degree two

Figure 1: Trendline fitting for different models

In the imaginary example shown in *Figure 1* it seems that the points are not following a linear dependence. Nevertheless, we may try at first to find a linear slope which balances the deviations as good as possible. Important for that is the decision if the straight has to pass the point of origin (or any other fixed point) or not. In a couple of cases it is clear from physical knowledge that the line has to meet the point (0; 0), although the fit, then, is not such good, as to see in parts *a)* and *b)*.

The mathematical technique to find the best fit is the least squares method. Using an eligible software the calculation of the curve is very easy. But again we have to feed the computer with technological knowledge because there is the need to determine the type of mathematical function, maybe exponential or polynomial. For a polynomial additionally the degree is to appoint. No higher than a quadratic term is meaningful in the most of technical applications (unless in the case of hysteresis or similar with degree three). In the example the decision between a logarithmic or a quadratic function depends on the fact if negative values of the quantity y are possible or not (In the logarithmic case there should be measured an additional value of y for x between 0 and 1.). As to see in parts *c)* and *d)* of *Figure 1* the fit is considerably different although its quality is nearly the same, characterised by the coefficient $R\_squared$ of determination.

But the value of $R\_squared$ has force of expression only under the precondition that the measured points are assured statistically. This is not the case when our six points are measured only once each. For easier comprehension we assume the values of x are exactly. Estimated error margins of y are outlined in *Figure 1*, parts *b)* and *d)*. A good fit of experimental data is found when the function line will cross all error bars. If we have little errors of measurement shown in *d)* the quadratic function is motivated. But if the bars are as long as in *b)* we can see that there is no serious reason to refuse the linear model.

Having a number of n scattering points it is always possible to find a polynomial of the degree $(n-1)$ which fits them exactly, but it is very improbably that a polynomial of maybe degree 5 will be the true description of a natural process or system. Thus we recognise that even a high value of $R\_squared$ is not an indicator for an adapted description. That's why it should be a rule to use the simplest function whose graph meets all error bars. From polynomials it is that with the minimum of degree. It's better to have a rough but in this extend correct approximation than a description with senseless precision. See also the adapted rounding of the values in the function equations in *Figure 1*.

In our example with long error bars as in *b)* the only serious conclusion from the experiment is that the quantity *y* is increasing with rising *x*. A horizontal line would not fit. Under the precondition of meeting the point (0; 0) a probable description of the relationship is a 0.7 slope. Mathematics gives us as formulas to calculate the confidence intervals of the regression coefficients which can't be discussed here. But already from experiences the relative uncertainty of this slope is conciderably. It would be wrong in fact to predicate a better knowledge. If there is no declaration of the measurement uncertainties all results are free from worth.

To summarise these **general remarks** we teach our students: In figures with experimental results

- ✓ mark the measured points clearly to visualize their scattering **but** not only show curves,
- ✓ never connect the points with pieces of straight lines **but** search for a proper fitting curve,
- ✓ use the values of measurement uncertainties for the decision of the type of the relationship (in the best way with the help of error bars), in doubt better use the easiest possible function.

First Order Factorial Designs

So far we have discussed the dependence of a quantity y from only one argument x. But in nearly all technological problems it isn't such easy. The output of a production system, e. g. yield of a chemical reaction, will normally be influenced by several input quantities, called **factors**. The traditional approach in research of the output, called **system answer** or **target quantity**, is to vary only one factor at a time, holding all the others constant. Changing the values of more than one input variable at the same time would mix their effects.

The 2^3 Factorial Design

Let's take three factors x_1, x_2, and x_3 with the standardised base setting denoted by (0; 0; 0). The varied values shall be named with the coded unit 1 for each factor. The experimental plan using the method "one-factor-at-a-time" (OFT) is shown in Part *a)* of *Table 1* (left). Using such an approach it is not possible to investigate the effect of one factor at modified levels of the other factors than their base setting. It may happen that the effect of a factor x_1 onto the system answer (let's assume positive) at the high level of a factor x_2 is just an opposite one (maybe even negative) at the low level of that factor x_2. That's why unknown **interaction effects** will make a generalisation of the conclusions definitely wrong.

Table 1: Design of Experiments (DoE) versus One-Factor-at-a-Time (OFT) for Three Factors at Two Levels

Treatment	x_1	x_2	x_3	Output
1	0	0	0	
2	1	0	0	
3	0	1	0	
4	0	0	1	

a) One-Factor-at-a-Time (left)

Treatment	x_1	x_2	x_3	Output
1	-	-	-	
2	+	-	-	
3	-	+	-	
4	+	+	-	
5	-	-	+	
6	+	-	+	
7	-	+	+	
8	+	+	+	

b) Design of Experiments (right)

Such interactions can't be investigated without proper DoE. Now there is no baseline setting in the former sense, that's why the factor levels in their natural units are standardised with a linear transformation to the coded values -1 and +1, shortly written as "-" and +".The design is shown in part *b)* of *Table 1* (right). The list with **treatments** of the system under investigation contains all possible combinations of the each two levels of the factors. A row for a special treatment in the design is also called **experimental point**. So we get with $k = 3$ factors and $l = 2$ levels a number of $a = l^k = 8$ lines. That's why the trial will be referred to as l^k factorial design generally, in this case the 2^3 factorial design.

The measurement results of the system answer under the different treatments will be written in their natural units into the column **Output**. For the calculation of all effects we have to extend the design table by one column "*I*" with "+" signs in all rows and additional columns for all interactions. The algebraic signs in the interaction columns are simply the products of the signs in the related columns. The matrix contains with eight lines for the treatments also eight rows for the factors, now it is a quadratic one as shown in *Table 2*.

Table 2: Design of Experiments (DoE) with Three Factors at Two Levels

Treatment	I	x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	$x_1x_2x_3$	Output
1	+	-	-	-	+	+	+	-	y_1
2	+	+	-	-	-	-	+	+	y_2
3	+	-	+	-	-	+	-	+	y_3
4	+	+	+	-	+	-	-	-	y_4
5	+	-	-	+	+	-	-	+	y_5
6	+	+	-	+	-	+	-	-	y_6
7	+	-	+	+	-	-	+	-	y_7
8	+	+	+	+	+	+	+	+	y_8
Effects	$\bar{y}$	$ME1$	$ME2$	$ME3$	$IE12$	$IE13$	$IE23$	$IE123$	
Coefficients	b_0	b_1	b_2	b_3	b_{12}	b_{13}	b_{23}	b_{123}	

An **effect** E is calculated as the difference between the arithmetic mean of the measured output with this factor at high level and the mean of the output values at low level of that factor. This applies to the **interaction effects** IE in the same way like to the **main effects** ME of the single factors according to the following equation. In this design here the sum goes over the rows $i = 1, \dots, 8$

$$E_{\dots} = \frac{\sum_{i=1}^{a} x_{i\dots} y_i}{a/2} \quad (1).$$

The column called "*I*" for the **zero effect** contains in the effect row the arithmetic mean of all output values

$$\bar{y} = \sum_{i=1}^{a} y_i \quad (2).$$

The interpretation is, that the values of the system answer will increase or decrease by the value of the effect depending on its arithmetic sign. Two factor interactions show synergy when both main effects are positive and the interaction effect is positive too. Other interactions have to be discussed in similar way.

The **regression equation** for the linear model with three variables is

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 + b_{13}x_1x_3 + b_{123}x_1x_2x_3 \quad (3).$$

The **regression coefficients** $b_{\dots}$ are the half effects $E_{\dots}$ but the coefficient b_0 equals to $\bar{y}$ according to

$$b_{\dots} = E_{\dots}/2 \qquad \text{and} \qquad b_0 = \bar{y} \quad (4).$$

With these results it becomes possible to calculate the output value expected for any constellation of the input variables, not only at their standardised levels "+" and "-" but also for arbitrary values in the natural units of the quantities.

Other First Order Designs

Two-level factorial designs are easily extendable to more than three factors. An additional factor will require the double number of runs. If the experimenter can reasonable assume that certain interactions are negligible, maybe at least those of three and more factors, it will be possible to reduce the number of treatments of a 2^k design by p times a half. Or with other words, k factors can be investigated with only 2^{k-p} rows in the design. In such a **fractional factorial design** each effect has $(2^p - 1)$ **aliases**. The type of these aliases is described with the so-called **resolution** of the design. For example in resolution III designs main effects are aliased with two-factor interactions, in resolution V designs two-factor interactions with three-factor interactions and no main effect or two-factor interaction are aliased with any other main effect or two factor interaction. The higher the resolution the less problematic is the interpretation of the results. To investigate the impact of even many factors on an output quantity of a system there are **PLACKET-BURMAN** designs [Several References] with resolution III. They are usable only for screenings because interactions are not observable.

Significance of Effects

With the help of equations (1) and (2) we calculated effects. But as discussed in the section before we have to take in account the uncertainties coming from disturbance. The measuring errors of the output quantity will propagate to the effects. For this reason some effects could result only accidentally but not be true. That's why they are to be proved for **significance**. To do this we have to know the **variance** of the system response. One possibility is to repeat the experiment often at least with one special treatment. A better estimation of the mean variation delivers a realisation of all rows $i = 1, 2, \dots, a$ in different random sequence n_i times, called **replication**. The experimental results then are y_{ij} with $j = 1, 2, \dots, n_i$. Assumed to realise all treatments equal times (all $n_i = n$) and to have the same true variance σ^2 of the system response independent of the special treatment the estimated variance s^2 is the arithmetic mean of the different sample variances s_i^2 of the treatment results.

For factorial designs of first order (linear model) the experimental variance of an effect can be calculated as the sum of the variances of the mean responses at high and low level of the factors

$$var(E) = s_E^2 = \frac{s^2}{an/2} + \frac{s^2}{an/2} = \frac{4s^2}{N} \tag{5}$$

with a total number $N = a \cdot n$ of measured single values. Choosing the **level of significance** α, that is the probability to predicate an effect although it is not true, the propagated **measuring error** ΔE of an effect is

$$\Delta E = \mathrm{t}(\nu, P) \cdot s_E = t\left(\nu; 1 - \frac{\alpha}{2}\right) \cdot \frac{2s}{\sqrt{N}} \tag{6}$$

with the **degree of freedom** ν for the estimation s^2 of the single values experimental variance. The values of $\mathrm{t}(\nu, P)$ are the quantiles of the **t-distribution**. A **true effect** η will fall into the **confidence interval**

$$E - \Delta E \leq \eta \leq E + \Delta E \tag{7}$$

in the environment of the calculated effect E. If this interval contains the value zero the effect is not proved to be existent really. That's why the related regression coefficient in the equation (3) has to be deleted.

From *Table 1* it seemed that DoE would need a double number of experiments in comparison with OFT. But now this has been found false. To detect significant effects it is not sufficient to realise the plan once. In OFT each effect is the difference between the system answers on two treatments, thus it has the variance $2s^2$ if the plan is realised only once. Let's assume we know the empirical variance from a pretest to be s^2 with the degree ν of freedom. When we have realised the OFT-plan twice the variance of an effect is $s^2/2 + s^2/2 = s^2$ and the error of the effect is proportional to s. But using DoE with the same number of eight runs the error of an effect is proportional to $2s/\sqrt{8} = \frac{1}{2}\sqrt{2}s$ according to (6). We realise that with DoE we have at the one hand a smaller error by the factor about $1/\sqrt{2} \approx 0.7$ and at the other hand much more information concerning the interaction of the variables. This double advantage results from the multiple benefit of all single experimental data. Like explained, the smaller error does help to prove an effect as significant.

Restrictions of the Linear Model

Coming from the dependence of a quantity y on only one argument x to the influence by several factors x_i we restricted their values at first to only two levels. This means to apply a linear model. This fact is very simple, but

the experimenter must not forget the danger of mistake in reasoning shot if the true dependence of y from (one of the) x_i doesn't follow the linear model restrictions.

As seen in *Figure 2* the increase of the output within the full set range (1… 6) of input is stronger in the range for instance (0… 3), but for example between the values 5 and 6 there is even a decrease. Moreover, if the input setting is just to 3 and 5 there would be the conclusion that the output doesn't depend from the input value at all. That's why in preparation of a DoE it is necessary to initiate a screening for proper choice of the variable's range to be investigated.

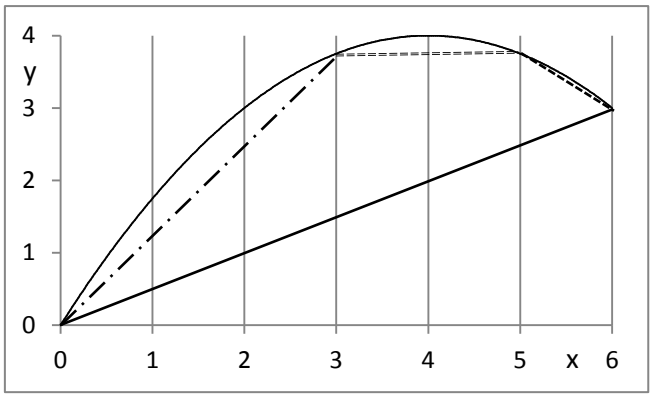


Figure 2: Linear model restrictions

Second Order Factorial Designs

If the experimenter can't reasonable assume that the investigated system is a linear one in the experimental range it is not sufficient to use only two levels of the factors, coming to a 3^k factorial design. In second order factorial designs with k input variables each of them has $l = 3$ levels with the standardised values (-1; 0; 1).

The 3^2 Factorial Design and other Second Order Designs

For a quadratic model with only two variables the table of the complete factorial design has already $3^2 = 9$ rows. But the **regression equation**

$$y = b_0 + b_1x_1 + b_2x_2 + b_{11}x_1^2 + b_{22}x_2^2 + b_{12}x_1x_2 \qquad (8)$$

has only six terms. Thus, this exhaustive design is over-determined. Nevertheless, with a mathematical trick it is not difficult to ascribe the calculation of the regression coefficients of a 3^k design to that of a 2^k plan in which the coefficient b_0 is no longer equal to $\bar{y}$. A special design for $l = 3$ levels and $k = 3$ factors is the **BOX-BEHNKEN** design [Several References]. This is a spherical design with all experimental points lying on a sphere of the radius $\sqrt{2}$. Designs containing the point (0; 0; 0) are called **central composite designs** (CCD). A CCD consists of a 2^k **factorial**, $2k$ **axial or star points** and a number of **center runs**. The levels of the factors at the star points have the value α what usually is not 1. For a spherical region of interest the best choice is to set $\alpha = \sqrt{k}$.

Whereas in linear models the maximum response always will fall onto one of the treatments, with second order models the maximum will be at any point inside or even outside the initial experimental region. **Response surface methodology** is a collection of techniques to optimise the response. Many response surface problems involve the analysis of multiple responses. The task is to find a set of operation conditions of the system that optimises all responses or at least keep them in desired ranges.

Analysis of Variance

Whereas for full two-level factorial designs the significance test of the effects is such easy like described in the section "Significance of Effects" (see above), for other designs (fractional, second order and others) another approach is necessary. The variability of the system answer may have different sources. The first source is the varying treatment, of course. But even if there wouldn't exist any effects of the changing levels of the input variables at all, there will be always some variance of the output values resulting from measuring errors. Finally, some defect can arise if the measured points are not explainable with the mathematical model (especially second order) used. The last can only be checked with an over-determined design (more treatments than regression coefficients), otherwise the model lack will be hidden in the error term.

The approach is the **partitioning** of the **total variability** into its component parts. Let's assume again to realise all treatments equal times, all $n_i = n$ with $j = 1, 2, \dots, n$. The total of observations under the i^{th} treatment is

$y_{i.} = \sum_{j=1}^{n} y_{ij}$ and the average is $\overline{y_{i.}} = y_{i.}/n$ (9).

Similarly, the grand total of all observations is

$y_{..} = \sum_{i=1}^{a}\sum_{j=1}^{n} y_{ij}$ and the grand average is $\overline{y_{..}} = y_{..}/N$ (10),

where $N = a \cdot n$ is the total number of observations. The **sample variance** of all measured values y_{ij}

$$s_{total}^2 = \frac{1}{an-1}\sum_{i=1}^{a}\sum_{j=1}^{n}\left(y_{ij} - \overline{y_{..}}\right)^2 \quad (11)$$

is the standard measure of **total variability**. Hence, we use the numerator

$$SS_{total} = \sum_{i=1}^{a}\sum_{j=1}^{n}\left(y_{ij} - \overline{y_{..}}\right)^2 \quad (12)$$

as a measure of the overal variability of the data. This **total sum of squares** may be written as

$$\sum_{i=1}^{a}\sum_{j=1}^{n}\left(y_{ij} - \overline{y_{..}}\right)^2 = n\sum_{i=1}^{a}(\overline{y_{i.}} - \overline{y_{..}})^2 + \sum_{i=1}^{a}\sum_{j=1}^{n}\left(y_{ij} - \overline{y_{i.}}\right)^2 \quad (13)$$

or shortly

$$SS_{total} = SS_{treatments} + SS_{error} \quad (14).$$

This is the **fundamental ANOVA identity** (proven e. g. in [1]).

The **treatment sum of squares**

$$SS_{treatments} = n\sum_{i=1}^{a}(\overline{y_{i.}} - \overline{y_{..}})^2 \quad (15)$$

of the differences between the observed treatment averages is a measure of the treatment's variability.

And the **error sum of squares**

$$SS_{error} = \sum_{i=1}^{a}\sum_{j=1}^{n}\left(y_{ij} - \overline{y_{i.}}\right)^2 \quad (16)$$

of the differences of observations within treatments from the respective average is due to measurement uncertainties.

For easier calculations it is useful to split the total sum of squares other way. It is not difficult to show that the sum of squares of the differences of the single measurement results from their mean for one treatment may be written as

$$SS_i = \sum_{j=1}^{n}\left(y_{ij} - \overline{y_{i.}}\right)^2 = \sum_{j=1}^{n} y_{ij}^2 - \frac{1}{n}\left(\sum_{j=1}^{n} y_{ij}\right)^2 \quad (17).$$

In the result of summation over all treatments the total sum of squares may be written after some conversions to

$$SS_{total} = \sum_{i=1}^{a}\sum_{j=1}^{n} y_{ij}^2 - \frac{1}{an}\left(\sum_{i=1}^{a}\sum_{j=1}^{n} y_{ij}\right)^2 \quad (18)$$

or shortly

$$SS_{total} = SS_{raw} - SS_{\overline{y_{..}}} \quad (19).$$

The quantities SS_{raw} and $SS_{\overline{y_{..}}}$ are only operands for an easier calculation of SS_{total} without a descriptive impact.

The term SS_{raw} is simply the **raw sum of squares** of all measured values according to

$$SS_{raw} = \sum_{i=1}^{a}\sum_{j=1}^{n} y_{ij}^2 \quad (20)$$

and the **zero effect sum of squares** $SS_{\overline{y_{..}}}$ may be written even easier as

$$SS_{\overline{y_{..}}} = \frac{1}{an}\left(\sum_{i=1}^{a}\sum_{j=1}^{n} y_{ij}\right)^2 = an\overline{y_{..}}^2 \quad (21).$$

Similarly to that the **regression coefficient sums of squares** are

$$SS_{b_{...}} = \frac{1}{n\sum_{1=1}^{a} x_{i...}^2}\left(\sum_{i=1}^{a}\sum_{j=1}^{n} x_{i...}y_{ij}\right)^2 = nb_{...}^2\sum_{i=1}^{a} x_{i...}^2 \quad (22)$$

because of

$$b_{...} = \frac{1}{n\sum_{1=1}^{a} x_{i...}^2}\left(\sum_{i=1}^{a}\sum_{j=1}^{n} x_{i...}y_{ij}\right) \quad (23),$$

compare (1) and (4) for n realisations of the a treatments, the former number a is now generalised

to $\sum_{1=1}^{a} x_{i\ldots}^2$ for second order models. The values of SS_{raw} and $SS_{\overline{y}_{..}}$ may be used to calculate SS_{total} simply.

All regression coefficients are used to characterise the model, the zero effect gives only an offset, that's why the **model sum of squares** is

$$SS_{model} = \sum_{\ldots \neq 0} SS_{b\ldots} \tag{24}.$$

That part of the total, which is not explained with the model is called **rest sum of squares** (leftover) with

$$SS_{rest} = SS_{total} - SS_{model} \tag{25}.$$

Combining equations (14) and (25) we get

$$SS_{total} = SS_{treatments} + SS_{error} = SS_{model} + SS_{rest} \tag{26}.$$

Because the error term only comes from measurement uncertainties any model defect has to be enclosed in the treatment term according

$$SS_{treatment} = SS_{model} + SS_{defect} \tag{27}.$$

Finally, the **model defect sum of squares** according (26) und (27) may be quantified as

$$SS_{defect} = SS_{rest} - SS_{error} \tag{28}.$$

The significance analysis is realised by the comparison of the variance of the effect to be proved with the variance coming from the disturbance causing measurement uncertainties. The dedicated standard test function is the expression

$$F_{exp} = \frac{s_1^2}{s_2^2} = \frac{SS_{b\ldots}/\nu_{b\ldots}}{SS_{error}/\nu_{error}} = \frac{SS_{b\ldots}}{SS_{error}/a(n-1)} = (N-a)\frac{SS_{b\ldots}}{SS_{error}} \tag{29}$$

because of one degree of freedom per regression coefficient and the count $\nu_{error} = a(n-1) = N - a$ for the measurement uncertainties. The effect of a variable is significant with the probability α of error, if $F_{exp} > F(1-\alpha; 1; N-a)$. The values of F are the tabulated quantiles of the **F-Distribution**.

Example of Use

A teaching example from packaging technology is the **seal strength** of special PP/PE polymer foils (here without further specification). The seal is made by a laboratory sealing device. Factors are the sealing temperature x_1, the sealing duration x_2 and the sealing pressure x_3.

Table 3: DoE for the Seal Strength with the Factors Temperature, Time and Force; all at Two Levels

2-to-the-power-of-3 design		Y=b0+b1*x1+b2*x2+b3*x3+b12*x1*x2+b13*x1*x3+b23*x2*x3+b123*x1*x2*x3									5,32	=F(0,95;1;8)
		Seal Strength							1256	1177	2432	SS(raw)
		Temp	Time	Force					1250	1174	2423	SS(y_dash)
SS (rest)									5,68	2,91	9,19	SS(total)
syst. No	x0	x1	x2	x3	x1*x2	x1*x3	x2*x3	x1x2x3	y	z	(y+z)/2	SS (Vers.)
1	1	-1	-1	-1	1	1	1	-1	10,6	11,1	10,85	0,13
2	1	1	-1	-1	-1	-1	1	1	12,8	12,3	12,55	0,12
3	1	-1	1	-1	-1	1	-1	1	12,4	11,6	12,00	0,32
4	1	1	1	-1	1	-1	-1	-1	13,0	12,7	12,85	0,04
5	1	-1	-1	1	1	-1	-1	1	11,8	11,4	11,60	0,08
6	1	1	-1	1	-1	1	-1	-1	13,2	12,6	12,90	0,18
7	1	-1	1	1	-1	-1	1	-1	13,2	12,5	12,85	0,25
8	1	1	1	1	1	1	1	1	13,0	12,7	12,85	0,05
	8	8	8	8	8	8	8	8				
	100,00	4,00	3,20	2,40	-3,20	-1,60	-0,80	0,00				
Reg.-Coeff.	12,50	0,50	0,40	0,30	-0,40	-0,20	-0,10	0,00				
SS(b...)	1250	2,00	1,28	0,72	1,28	0,32	0,08	0,00	0,00			
	96,90	3,70	2,10	1,50	-1,10	-0,90	0,30	-0,90				
Reg.-Coeff.	12,11	0,46	0,26	0,19	-0,14	-0,11	0,04	-0,11				
SS(b...)	1174	1,71	0,55	0,28	0,15	0,10	0,01	0,10		0,00		
	98,45	3,85	2,65	1,95	-2,15	-1,25	-0,25	-0,45				
Reg.-Coeff.	12,31	0,48	0,33	0,24	-0,27	-0,16	-0,03	-0,06				
SS(b...)	2423	3,71	1,76	0,95	1,16	0,39	0,02	0,05			1,17	1,17
Fexp=SS/s^2	16639	25,45	12,06	6,53	7,94	2,68	0,11	0,35			s^2 =	0,15

The temperature is given in degree Celsius with the levels 165 and 185. The duration, called time, has the values 0.8 and 1.2 in the unit seconds. The pressure is applied in terms of the force in Newton over the sealing stamp

with the width 10 mm to the sealed polymer strip with the broadness 25 mm, the level values in natural units are 150 and 250. The strength is measured in accordance with the German standard DIN 55529, not broad based in the unit N/m, but only as force in N to break the seal with the width 25 mm.

In *Table 3* the 2^3 factorial design can be seen with the experimental data after only two replications (shortened for training). The row last but two contains the calculated regression coefficients for the linear model including all interactions after two runs of the plan. Also all computations for the ANOVA are possible with the help of this EXCEL sheet. In result of the analysis of variance only those effects with an error $\alpha < 5\%$ are significant whose $F_{exp} > F(0.95; 1; 8) = 5.32$. All main effects are positive, that means, the seal becomes stronger at the high levels of all three factors. The largest influence has the temperature. But remarkable is also a significant negative interaction between the temperature and the time. All other interaction effects are only a result of random. The value 1.17 of SS_{rest} is equal to the value of SS_{error} because SS_{defect} is zero. Here is no model defect because the design is not over-determined. Hence, in this two-level factorial design SS_{model} is equal to $SS_{treatments}$. This will change if an additional treatment will be added, favourably a center point with all variables at mean level. Other designs can be discussed on the basis of transparent sheets according to this example.

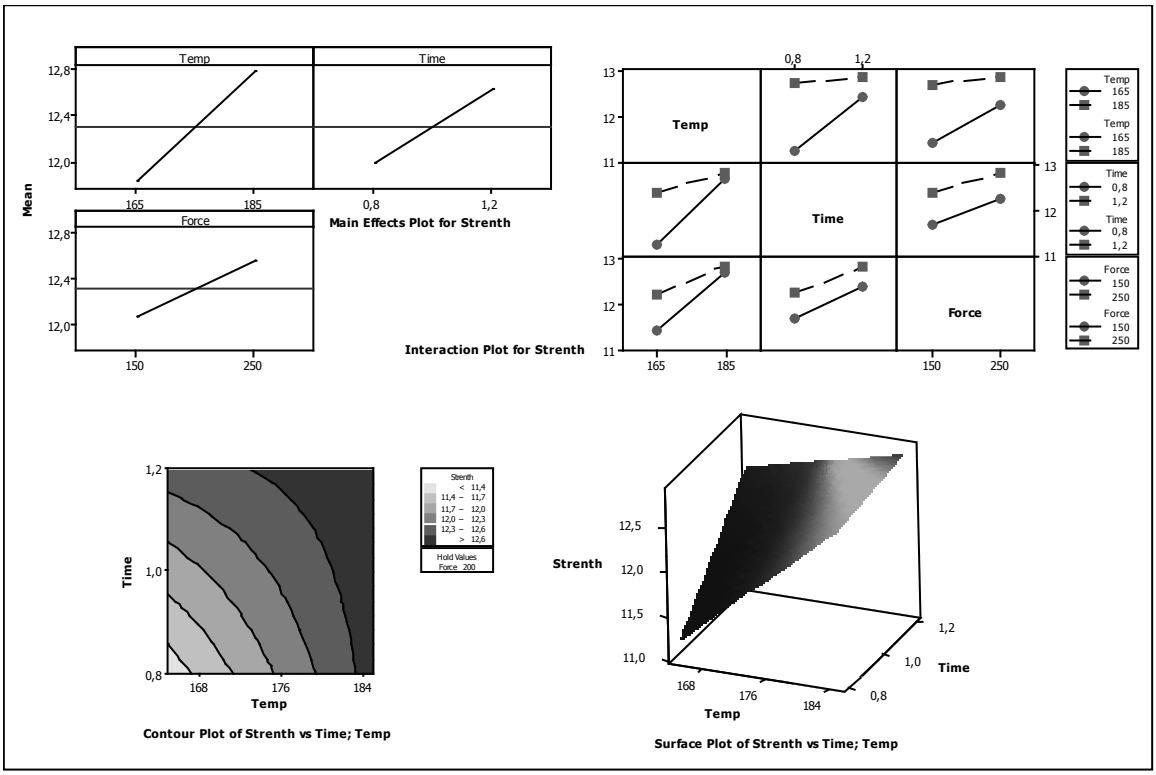


Figure 3: Effects of the the factors temperature, time and force to the seal strength; linear model

The measured values were also appraised with a software bundle, in particular it was used MINITAB®. Of course, the calculated effects are the same. The program also allows some useful plots, some of them can be seen in Figure 3. The combination of the influences of temperature and time are visualised in the **interaction plot** for strength. The positive temperature effect is strong with short sealing duration but considerably weakened with rising time length. Because of this interaction the response surface is not a flat plain in the **surface plot** and the **structural contours** are not straight lines over temperature and time. This is noteworthy for the linear model.

Guidelines for Designing Experiments [1]

It's necessary for the experimenter to have a **clear idea in advance of the system or process** is to be investigated. The procedure of DoE involves not only the design itself **but** moreover its planning and discussion. The following steps can give a roadmap:

1. Recognition and statement of the **problem**
2. Choice of **output quantities** (called "response variables")
3. Selection of **input quantities** (called "factors") and their ranges

4. Determination of the **experimental design**
5. Specification of the **factor levels**
6. Performance of the **experiments**
7. Statistical **analysis** of the data
8. Conclusions and **recommendations**

Students need to have a deep understanding of how the data are to be collected and of how these data are to be analysed. They should keep in mind the following advices:

a) Use your **non-statistical knowledge** of the problem.
b) Keep the design as **simple** as possible.
c) Recognise the difference between statistical and practical **significance**.
d) Don't forget the **restrictions** in whose frame the results are valid.

Last, but not least, experimental data must never be accepted uncritical!

Conclusion

Statistical methods can not only greatly increase the efficiency of experiments but they are inevitable to avoid errors in the interpretation of the measured data. It is shown in this paper that a certain mathematic knowledge is necessary to understand how significant effects are to be separated from random disturbance. The author of this treatise is convinced that it would be wrong to make the students believe that proper software would solve all problems itself. Learning by doing in project work is only possible on the fundaments of a deep understanding of the theoretical basis. To achieve real skills in utilisation computers generally three steps are recommended:

- ✓ Set very simple examples to calculate them manually in application of the mathematical basics.
- ✓ Write simple programs yourself (e. g. using spreadsheet) and compare the results with the previous step.
- ✓ Use sophisticated software at first to compute the same simple examples from the previous step and compare the results.

With such an experience you will be able to exploit the software to solve difficult problems. Only this way you will be able to understand really what the computer is doing and only with this background you are prepared to react on unexpected occurrences and to avoid misinterpretations.

Concerning DoE there are chapters in many modern text books on quality management. But the explanations are often as short that a misunderstanding is predetermined. On the other hand there are some very good specialised books. But the mathematical requirements are rather high, why engineers often shy to delve into them. From this reasons professors at universities of applied sciences have to concentrate the theory scholarly for practical applications and enforce the students as well as to help them on the way of the three steps mentioned above.

The approach shown here is a very short excerpt from the module DoE which the author is teaching in courses of printing and packaging technology. It may serve as an example for the demand to use statistical knowledge in engineering. Those of the readers who haven't access to DoE yet it should give an overview and maybe an easy entry into the matter.

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Author biography

Dr. rer. nat. Frank Roch (PhD in experimental physics) works as a Professor for Measurement Technology and Quality Management at the Faculty of Media of Leipzig University of Applied Sciences (HTWK Leipzig, Germany). In this frame he is teaching also holographic methods in protection against forgery (security technology) as well as Design of Experiments for students in bachelor's and master's courses in printing and packaging technology. At his faculty he is the departmental coordinator for international relations and in this task the contact person from HTWK Leipzig to the IC for many years.

PPT Design for Graphic Communication:

A Contrastive Study

Sheru Zhang

Beijing Institute of Graphic Communication, Beijing, 102600, China

Keywords: PPT design, contrastive study, multimedia learning, multimodal congruence

Abstract:

This paper investigates PPT graphic designs used in teaching graphic communication at Beijing Institute of Graphic Communication (BIGC). A small corpus consisting of 50 PPT samples was compiled as our empirical base of investigation. The PPT corpus comes from two settings, the face-to-face classroom, and the virtual classroom. Adopting Gu's scheme of classification (2007), the PPT designs are described in terms of (1) multimodality, i.e. mono, dual, and multi-media; (2) operability, i.e., automatic, teacher-operated, and learner-operated; (3) synchronization, i.e. no synchronization, voiceover synchronization, presenter synchronization; and (4) overall design orientation, i.e., message-oriented design, emotion-oriented design, and mixed type design.

The PPTs in our corpus are all used for instruction. In other words, the PPTs, no matter what descriptive categories they are found belonging to, can be evaluated in terms of instructional effectiveness. This constitutes the evaluative phase of our investigation. Theories about multimodal and multimedia learning and teaching as formulated by Gu (2008) and Mayer (2005) are adapted as our guiding principles for PPT evaluation. Specifically Gu's principle of multimodal congruence, Mayer's principles of split attention, and Gu's PPT: From practice to theory are put to test against our PPT corpus. It is found that some are poorly designed: either mono text transfers or solely picture display. When explaining concrete items like photographs and drawings, such as some Chinese mascots: PAN CHANG and phoenix or TAI JI diagram without visual-based medium would be difficult for teachers to explain and vague for learners to comprehend, but only some drawings or symbols on PPT without proper word statements can easily cause learners confusion especially for learners in virtual classroom. To cross check our findings, some real life learners are invited to evaluate the sample PPTs from the learner's perspective. At last the paper provides some suggestion for effective PPT design and for later reference and research.

1. Preliminary Remarks

Microsoft PowerPoint, an application enabling the presentation of multimedia content in the manner of slide show, is widely used in the multimedia classroom all over China. The acronym PPT has almost become an independent word with a sense of its own, that is, it refers to the product one makes aided by the PowerPoint. This is the sense of *PPT* we use in this paper. The phrase *PPT design* hence refers to the design of a set of slides that constitute a session of presentation dealing with a particular topic in question. For sake of analytic clarity, we specify our usage of terms as follows.

(1) A PPT: meaning a set of slides designed for a particular purpose; PPTs meaning sets of slides designed for different purposes;
(2) PPT design: meaning the design of a set of slides as a whole;
(3) Slide design: meaning the design of a particular slide as a whole.

For the present study, we have compiled a mini corpus consisting of 42 PPTs, with a total of 2510 slides, all collected at Beijing Institute of Graphic Communication (BIGC). They are all made to facilitate classroom instruction and all are art design based. Therefore they are analyzed and evaluated in terms of pedagogical effectiveness and efficiency.

The paper consists of 5 sections. Apart from this introduction, Section 2 gives a general account of the PPT corpus in terms of such design features as (1) multimediality, i.e. mono, dual, and multi-media; (2) operability, i.e., automatic, teacher-operated, and learner-operated; (3) synchronization, i.e. no synchronization, voiceover synchronization, presenter synchronization; and (4) overall design orientation, i.e., message-oriented design, emotion-oriented design, and mixed type design.

Section 3 outlines the theories we adopt as our analytic framework against which the PPT designs as well as slides designs are critically assessed. Featured prominently are Gu's theory about multimodal, multimedia and multiple environment learning (3-M learning theory for short), and Mayer's theory of multimedia learning.

Section 4 presents such case studies as some detailed analysis of PPT design samples as well as slide design samples.

The paper concludes with reflections and discussions of some remaining issues yet to be dealt with.

2. PPT design: features and classifications

2.1 Elements of design

As mentioned above, we look at PPT design both as a whole (i.e. a set design) and a part (i.e. slide design). The elements of the design (or ingredients of the design) include: (1) orthographic texts, (2) some essential elements for drawing, such as some Chinese traditional cultural elements, (3) sound clips, (4) tables, charts and drawings, (5) video clips, and (6) still images used for teaching how to design or how to appreciate varieties of master pieces.

Design by definition means the designer's choice making of these elements to produce a pattern of representation.

Let's take the PPT with title "Appreciation of western and eastern art" as an example. Based on Gu's scheme of classification, its PPT falls into multimedia for face-to-face instructional presentation in classroom setting. The teacher employed elements ranging from orthographic texts, sound music clips to some still images such as pictures, classic architectures or some drawings as assistance to help illustrate and comment on how to appreciate exquisite art works. From students' perspective, in light-music filled relaxing environment, they can appreciate the beautiful pictures or drawings while listening to the teacher's explanation assisted by orthographic texts for deep comprehension, instead of just imagining the teacher's sole oral abstract description. Such multimodal PPT assisted presentation is obviously more effective than singly orthographic texts display. The proverb that a picture is worth a thousand words attests to the popu1arity and acceptance of elements of design in PPTs. The multimedia PPT for "Appreciation of western and eastern art" obviously corresponds to Mayer's *multimedia principle* (2001) that adding pictures to words, rather than presenting text a1one, makes it easier for peop1e to understand and learn, and that peop1e 1earn more or more deep1y when appropriate

pictures are added to text.

2.2 Parameters of design

Gu (2007) (Gu Yueguo, 2007. PPT: From Practice to Theory. Plenary speech delivered at China 2007 Conference on Online Foreign Language Education, Weihai, China) recommends a scheme of classification of PPT in terms of the parameters mentioned above. Adopting the classification scheme, our PPT corpus can be described as follows.

Multimediality

There are 11 mono-medium PPTs, i.e. either text or pictures or drawings dominated rather than both text and picture appearing on the same slide; 16 dual-media PPTs, i.e. Dual Media – text + graphic on the same slide; and 12 multimedia PPTs, i.e. text + graphics + audio + video on the same slide.

Operability

Generally there are four forms of operability: (1) Auto-play, (2) Speaker-control, (3) Lecturing-voice-control and (4) user-control. Among 42 PPT corpus, whether mono, dual or multimedia PPTs, over 85% are operated in a Speaker-controlled way, which facilitates teacher /speaker' manipulation of lecturing speed, and adjusts to the concrete teaching situation. A few PPTs are auto-played. This happens usually when the teacher asks his or her students to review what have been taught or learnt, and what needs to be prepared by them. In face-to-face classroom environment, PPT is seldom user-controlled duo to the limited facilities and duo to stereotyped teaching modeling --- teacher-centered. Whereas, in virtual learning environment, PPTs uploaded to Internet usually are adopted user-controlled way. Hardly did we find any PPTs in our corpus lecturing-voice-control. This is mainly attributed to the lower-tech multimedia facilities.

Synchronization

Synchronization is the way of enhancing PPT effect. Voiceover synchronization and presenting speech synchronization are two strikingly powerful ways high frequently used in the 12 multimedia PPT corpus. How to embody Chinese traditional elements such as Chinese mascot: CHANG PAN and phoenix or TAI JI, in designing logos for different companies is the typical sample of integration of the above two synchronizations. This PPT displays orthographic texts and the pictures by Voiceover synchronization and presenting speech synchronization, thus enhancing and strengthening students deep comprehension and stir up their inspiration. When teaching how to compile and create the scenario of animation cartoon, one of the mono-text PPTs is played but synchronized by Narrative voiceover and sample animation, making the lecture vivid and impressive.

Orientation

Orientation is another parameter for designing PPTs. Overall design orientation includes message-oriented design, emotion-oriented design, and mixed-type design. 32 PPTs out of our 42 PPT corpus are message-oriented, 1 is emotion-oriented and 9 are mixed-type.

3. Theoretical framework for analysis and assessment

This paper takes Mayer's theory of multimedia learning and Gu's 3-M(multimodality, multimedia and multi-environment) learning theory as main theoretical framework. Their theories on "both basic and advanced

multimedia learning principles including Split-attention principle, Modality Principle etc. and PPT: From Practice to Theory" provide theoretical foundation for global technology-assisted instruction. That also accounts for why this paper chooses the theories as fundamental theoretical basis.

3.1 Mayer's theory of multimedia learning

Based on Mayer, multimedia refers to integration of media used for presenting words (such as printed text or spoken text), and pictures (such as illustrations, photos, animation, or video). Multimedia can build mental leaning representations from words and pictures to facilitate abstract and complicated concepts. Multimedia can also present words and pictures instruction that are intended to promote leaning and stimulate and hold learners' enthusiasm for learning.

Multimedia involves presenting material in two or more forms, then an important issue concerns how to characterize a form of presentation. Three solutions to this problem are the delivery media view, the presentation modes view, and the sensory modalities view. According to the delivery media view, multimedia requires two or more delivery devices, such as computer screen and amplified speakers or a projector and a lecturer's voice. According to the presentation modes view, multimedia requires verbal and pictorial representations, such as on-screen text and animation or printed text and illustrations. According to the sensory modalities view, multimedia requires auditory and visual senses, such as narration and animation or lecture and slides, PPT included. Multimedia learning occurs when people build mental representations from words (such as spoken text or printed text) and pictures (such as il1ustrations, photos, animation, or video). *Multimedia* refers to the presentation of words and pictures, whereas *leaning* refers to the learner's construction of knowledge. The process by which people build mental representations from words and pictures is the focus of Mayer's cognitive theory of multimedia learning.

3.2 Gu's 3-M learning

Gu's 3-M learning means people learn multimodality via multimedia in multiple environments, viz. 3M Learning.The 3M learning is a theorization of what is labeled as "5-any learning", viz. learn by anyone, anywhere, anytime, at any pace, in any manner. Gu strong advocates multiple interactions. We human beings interact with the outside world with all our sense organs; we learn with our brain and body; we should learn the way our brain and body like us to; We can stretch our brain and body to their limits, but not beyond. Gu also strongly advocates that a coding system should be given top consideration. The coding system involves oral verbal coding, written verbal coding, drawings, animation, pictures, filming etc.. The most ideal is by blending some or all. When designing instruction, the following three factors should be taken into consideration: (1) Mental states including wakefulness, excitement, invigoration, attention control; (2) Instructor's process management over space and time; Immediacy of Teacher & Classmates. What's more, designing instruction should be within brain and body limits, which means cognitive qualities such as attention span over time, working memory span, internal distracters, external distracters, mental fatigue, and physical fatigue are all necessary elements when doing technology-based instruction plan.

3.3 Gu's scheme of evaluative parameters

Gu (2007), apart from the classificatory scheme discussed above, also presents a scheme of evaluative parameters, which is reproduced below:

The first parameter is Content design. The four aspects falls into this regard: (1) Visualization of abstract concepts; (2) Integration (text, image, sound, graphics, video); (3) Multimodalization and vicarious experience learning; (4) Multimodality congruence.

The second parameter refers to Effect enhancement, which can be further specified as three kinds (1) Synchronization including Multimedia synchronization, Voiceover synchronization and presenting speech synchronization; (2) Narrative voiceover; (3) Animation.

The third parameter is with respect to Channeling the Audience attention and working memory. Four sub-parameters are dealt with here: (1) Meta-cognition (Hierarchy, Discourse structuring, Content navigation and Cognitive offloading); (2) Focus; (3) Difference and contrast; (4) Interactivity.

Just based on the above theories and evaluative parameters, the paper does the following investigation and case analysis.

4. Data analysis: some case studies

Technology-assisted education has gained great popularity throughout the world. Multimedia facilitates teaching complex visual-based graphic art. We can imagine the difficulty of describing Chinese traditional symbols applied in designing logos in business world, such dragon, phoenix, golden fish, Pan Chang etc. in words. In this sense, PPT contributes a lot to graphic art education, because PPT has powerful function of synchronizing words, drawings, pictures, audio, video, and animation to convey a large amount of information simultaneously. It is one the significant tools of visualization, an aid to human cognition, and important role in presentation, thus spurring thinking in visual rather than in abstract, symbolic terms, consequently enhancing learning by intuitional instruction of graphic art design. So in this section, the paper will take Gu's Evaluative Parameters as theoretical basis and choose 3 kinds of PPTs from our corpus as cases to do contrastive study.

The paper selects two PPTs with the same title for contrastive study. Both are message-oriented, one being mono-media PPT with either orthographic texts or only pictures, the other belonging to dual-media category with Synchronization of graphics and text together. The paper investigates and analyzes the two cases according to Gu's five evaluative parameters: (1) Content design, (2) Effect enhancement, (3) Channeling the Audience attention and working memory, (4) PPT Operation, (5) External resources integration.

The first PPT that the paper wants to investigate is a dual-media PPT with title: *The application of Chinese mascots in the design of modern logo*. Its instructional aim is to explore how designers integrated Chinese traditional typical mascots or lucky symbols with contemporary elements to create the impressive images for enterprises through both cultural and social features. From the angle of content design, this PPT visualizes the elements of design (see PPT 1) and integrates text description and graphics together to facilitate both instruction

and comprehension.

Figure 1. The Dual-Media PPT Design of Chinese Mascot "Panchang" in Modern Logo

Besides, this PPT is presented by speech synchronization and animation, which can highlight the focus of the instruction and hold learners' attention.

This PPT design accords with Mayer's idea that instructional messages should be designed in light of how the human mind works. Based on Mayer, humans have two information-processing systems - one for verbal material and the other for visual material. When we present material only in the verbal mode, we are ignoring the potential contribution of our capacity to also process material in the visual mode. In the process of trying to build connections between words and pictures, learners are able to create a deeper understanding than from words or pictures alone. Just as Gu said "We human beings are born multimodal animals". That explains why people learn better from words and pictures than from words alone, or people can retain longer memorization when learning through multimodality.

The contrastive PPT that the paper wants to investigate is a mono-medium PPT with the same title: *The application of Chinese mascots in the design of modern logo*. This second PPT sets the same objective as the first one, applying Chinese traditional mascots – phoenix into modern logo design but it is differently designed as follows (see PPT 2) :

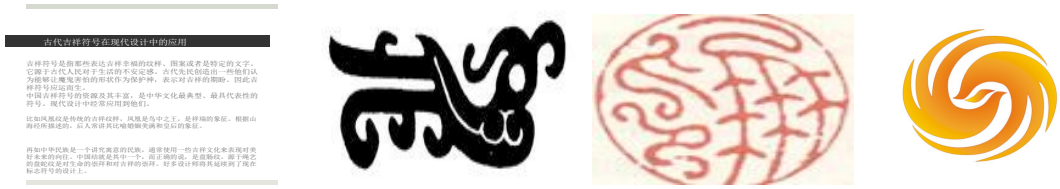

Figure 2. The Mono-Medium PPT Design of Chinese Mascot "Phoenix" in Modern Logo

This second PPT puts the text on one slide as explanation and puts graphics on the other slides as visualization of abstract concepts. It actually disintegrates the designing elements and hinders learners from establishing connection between words and pictures. It does not do anything to enhance the effect, no content navigation, multimedia synchronization, or animation, thus reducing the working memory and increasing brain working load. Moreover, it fails to design any interaction with learners, and it is also easy to cause learners' confusion.

The third PPT that the paper wants to investigate is a multimedia PPT with title: *How to compile and create cartoon scenario*. This PPT contains 78 slides, most of which are multimedia in feature. In terms of content design, it is message-oriented, integrated with audio explanation coupled with text/script and video to demonstrate the existing categories of current cartoon, outstanding writers of cartoon scenario, styles of cartoon art, and market share. The PPT visualizes all abstract concepts and offers learners multimodalization and vicarious experience learning. Meanwhile, it employs various means of effect enhancement, such as multimedia synchronization, voiceover synchronization and animation. These means just abide by learning rules--- Learning

is defined as alteration in long-term memory, which tells us almost all-human cognitive activity, is determined by information held in long-term memory. However, acquiring and dealing with any novel information calls for working memory, which is responsible for dealing with the new information or problem solving, then familiarizing, organizing the novel information, and finally storing in long-term memory. It is this store of information in long-term memory that constitutes expertise. Good PPT design can assist in reinforcing memory. In regard to the Channeling the Audience attention and working memory, this PPT logically designs the discourse structure, and use animation to highlight the focus and attract learners' attention. For instance, when analyzing and appreciating Japanese cartoon, this PPT utilizes presenting speech synchronization and narrative voiceover while introducing "Cartoon is a kind of newly-born media falling in between words and graphics. With the increasing prosperity of movie and television, words-based media will be declining. By contrast, cartoon will become popular day by day". With the beautiful voice, the PPT begins its auto-play in a natural way of content navigation, thus not only arousing learners' curiosity and interest, but also remaining controlled.

In order to provide learners adequate samples, this PPT designs multi-dimensional interaction: learners to print textbooks and to hyperlinked resources. Consequently, this PPT aided by multimedia and multimodality makes complex information accessible and cognitively tractable, and make learners think in visual rather than in abstract and symbolic terms. So this PPT is theoretically meta-cognitive and hierarchy, realizing its powerful function of visualization for depicting complex phenomena that may otherwise remain opaque or inaccessible.

5. Reflections and discussions

The analysis of the above cases suggests that with modern sophisticated technology, multimedia learning has become inevitable. Based on Gu's theory of multimodal congruence, people learn better from texts, audio and video than just from texts, because human beings are born multimodality. PPT is one of the important media, and plays the role of facilitating both learning and teaching, especially in the instruction of graphic art. So PPT design is heavily concerned. Good design of PPT can both visualize the abstract concept and help comprehend and cultivate learners' special imaginative ability.

The powerful function and significance of PPT design are crystal clear. The issue for further reflection and discussion lie in the following aspects: First, what way to teach graphic art design can be more effective and efficient: with verbalization, without verbalization, or with combination of verbalization and visualization? Second, when mentioning mono-dual- multimodalities, can we absolutely judge multimodal learning is better than mono or dual modal? Third, when evaluating PPT design, whether the criterion should be the more media used and the more information contained in PPT, the better? Fourth, because people learn better from graphics and narration than graphics and printed text separately based on split-attention principle and modality principle, how can we take advantages of powerful function of PPT to integrate words and pictures physically and temporally so that reinforcing working memory and reducing cognitive load to assist instruction?

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Author biography

Zhang Sheru, female, Master's Degree of Art, is professor and Director of Foreign Language Department of Beijing Institute of Graphic Communication, China. Her research focus lies in the applied linguistics and contrastive study in western and eastern culture. She also shows interest in the study concerning feminism media culture. Her magnum opus is "On Correlation between Multimodal Teaching and Learning internalization" among over 30 pieces of her publications.

A Proposal for Print Automation Seminars In Europe

James Harvey, Executive Director
CIP4

executive_director@cip4.org

While Print Automation with JDF-enabled tools has been adopted by many printers, there is still a large number of printers that don't have the information they need to plan and manage print automation implementations. Within North America, approximately 28% of printers have no plans to automate their operations and the leading reasons are a lack of understanding of the ROI for automation and the skills necessary to manage an implementation, and while no similar survey data is available for Europe, it is believed that there is a similar need in Europe. CIP4 has had success teaming with Universities and its members propose tackling this issue in Europe by partnering with interested universities. CIP4 Executive Director Jim Harvey will provide an overview of a proposed agenda, as well a framework for partnering with Universities and the CIP4 members that have expressed an interest in this program. The goal of this session is to open a dialogue with International Circle member universities in order to organize and produce a series of seminars on the topic of print automation across Europe in the early winter and spring of 2014.

Improving the Yule-Nielsen modified spectral Neugebauer model using Genetic Algorithms

Yiming Qian[1], Nawar Mahfooth[2], Matthew Kyan[1]
[1]*Ryerson University, Canada*
[2]*Smartia Printing Technologies Inc., Canada*
yqian@ryerson.ca, nawar@smartia.ca, mkyan@ee.ryerson.ca

Keywords: Colour Printing, Dot Gain, Spectral Prediction Model, Yule-Nielsen modified Spectral Neugebauer model, Genetic Algorithm

Abstract

Yule-Nielsen Modified Spectral Neugebauer model is widely used in colour prediction but different physical factors such as light scattering in substrates, ink chemical properties and ink drop velocity all influence the accuracy of the prediction. In this paper, we are presenting a method that uses the standard IT8.7/4 CMYK test chart and YNSN dot gain enhanced model to construct paper-ink-printing machine dependent prediction models. IT8.7/4 was printed on an offset press with 100lb coated paper. PressSign software was used to control the ink keys along with an X-Rite eXact to ensure the densities were within GRACoL specifications; 10 measurements were obtained after 24 hours using the iSis (a spectrometer). The measured data was smoothed and averaged to obtain clean spectral data. The 16 Neugebauer Primary colours (NPs) and 4 dot-gain curves were extracted from spectral data. Genetic algorithms were used to fine-tune the dot gain curves and at the same time to find and optimize the spectral *n* value (different *n* for different wavelength range). The final model used YNSN model as a base, instead of using only one *n* value, 36 *n* values based on the spectral measurements were used. The dot gain model was used to correct the input value before feeding to the YNSN model. Our contribution in this paper was to improve the Yule-Nielsen modified Neugebauer model by integrating a genetic algorithm for computing the dot gain of the CMYK's and finding a set 36 spectral *n*-values.

Introduction

Yule-Nielsen Modified Spectral Neugebauer (YNSN) model is widely used in colour prediction but different physical factors such as light scattering in the substrate (paper), ink absorbing into the paper, ink spreading out into the paper, all influence the accuracy of the prediction. Different paper types have different ink absorption rates: for example, uncoated papers can absorb more ink than coated ones. As paper is passed through a printing press the pressure of the plates can squeeze the ink out of its dot shape causing gain and result in different shapes on the paper. Different inks under the same pressure will also obtain different dot gain due to its own characteristics [1]. Some of those physical properties appear in the printing result in the form of dot gain. The dot gain describes the phenomenon associated with ink spreading around halftone dots imparted to the substrate, and leads to a darker colour appearance than intended [2]. In the YNSN model, those properties are partially corrected by applying a single *n* factor (equation 1) across all wavelengths, when associating the measured with theoretical reflectance of a particular ink set. However, ink reflectance at different light wavelengths may exhibit very different behaviour with a given substrate. As such, a spectral *n*-value model is used to further improve the YNSN model [3]. The spectral *n*-value model assigns different *n* factors on each wavelength but those *n* factors are often hard to determine. The most popular way is using training data and linear regression to estimate the parameters based on the least square error [4]. Linear estimation methods cannot accurately estimate the inks' nonlinear features due to those nonlinear parameters' complex relationships.

The method proposed in this paper offers a novel approach to fine-tune the dot gain and estimate the spectral *n* factor parameters at the same time by using an optimization procedure based on the Genetic Algorithm (GA). The advantage of this algorithm is that it is capable of finding a set of optimal parameters simultaneously, instead of finding them individually [4,5]. In the proposed method, the genetic algorithm is applied to process a set with 123 parameters at once. The flow chart of the process is shown in Figure 1.

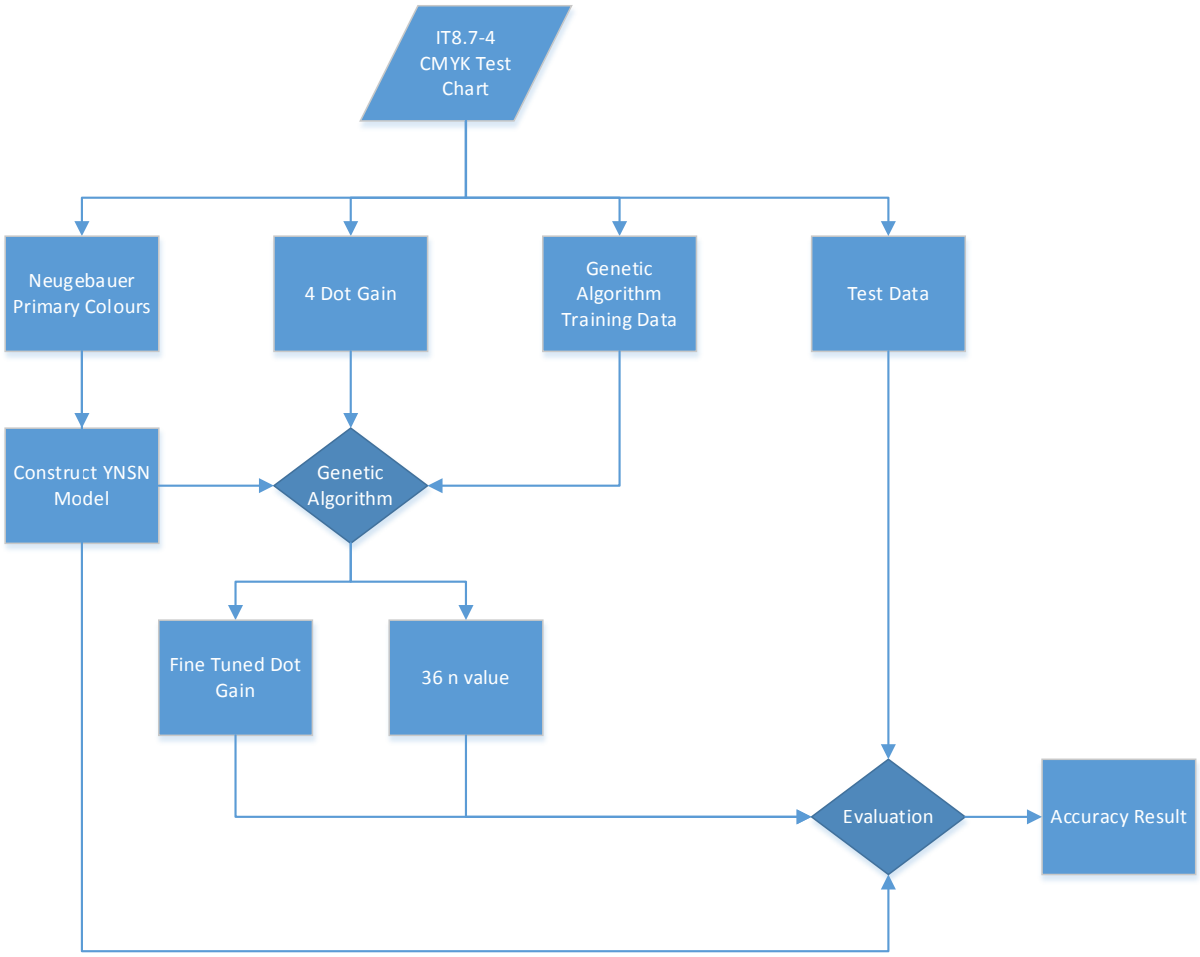

Figure 1: Dot Gain Fine-Tuning and n Factor Estimation Process Flow Chart

Yule-Nielsen Modified Spectral Neugebauer Model

The Yule-Nielsen Modified Spectral Neugebauer (YNSN) Model considered the effect that light laterally scatters within the paper which leads to an increase in the probability of the ink dots absorbing the light [6]:

$$R_\lambda = [\sum_{i=1}^{N} F_i R_{\lambda,i}^{1/n}]^n \quad (1)$$

Where

F_i is the fractional area coverage of the Neugebauer Primary colour
$R_{\lambda,i}$ is the measured reflectance
n is the Yule-Nielsen factor
R_λ is the calculated reflectance of the ink mix

Typically, four situations are considered for how light is reflected from paper. First, the light hits a printed dot and reflected from it. Second, the light hits the paper and reflects through a printed dot. Third, the light hits the paper and reflects without interacting with any printed dots. The last situation is that the light is absorbed by the paper, and thus never reflected out [7]. The model in equation (1) attempts to predict the reflectance of a particular ink mix given the measured reflectances of individual ink primaries used, while accounting for these four reflectance situations (embodied in the parameters F_i and n respectively).

The primary inks produce solid ink elements as well as overprints. Those colours are referred to as Neugebauer Primary Colours (NPs). The traditional CMYK system has 2^4 Neugebauer Primary Colours (16 NPs). Each colour has a fractional area coverage, which represents the probability that each Neugebauer Primary Colour covers the paper. The fractional coverage can be calculated by following equation:

$$F_i = \prod_{j=1 \to N} (\text{If ink } j \text{ is in Neugebauer Primary } I, \text{ then } a_j \text{ Else , } (1- a_j)\ ) \quad (2)$$

Where

a_j is the effective area coverage of ink j.

Table 1 Calculation of the area coverage for each Neugebauer primary given the concentration of inks

Index	Neugebauer Primary (*I*)	Area Coverage (F_i)
1	W	(1-c)(1-m)(1-y)(1-k)
2	K	(1-c)(1-m)(1-y)k
3	Y	(1-c)(1-m)y(1-k)
4	YK	(1-c)(1-m)yk
5	M	(1-c)m(1-y)(1-k)
6	MK	(1-c)m(1-y)k
7	MY	(1-c)my(1-k)
8	MYK	(1-c)myk
9	C	c(1-m)(1-y)(1-k)
10	CK	c(1-m)(1-y)k
11	CY	c(1-m)y(1-k)
12	CYK	c(1-m)yk
13	CM	cm(1-y)(1-k)
14	CMK	cm(1-y)k
15	CMY	cmy(1-k)
16	CMYK	cmyk

Dot Gain Model

During the printing process, the ink that is dropped on the paper will spread out and increase its size. This ink property is well known as dot gain. There are two types of dot gains "Mechanical Dot Gain" and "Optical Dot Gain". The mechanical dot gain is the ink size gain due to the physical movement of the liquid ink and is the dominant effect in any dot gain process. The optical dot gain is caused by light reflection between the ink dot edge and paper, which is usually seen as a blur effect of the ink drops. In this paper, the dot gain reflectances are measured by spectrometer on the printed result of an IT8.7/4 test chart. The traditional way to calculate dot gain is the Murray-Davies equation:

$$DotGain = \frac{R_0 - R_N}{R_0 - R_{100}} \times 100 \quad (3)$$

Where

R_0 is the reflectance of paper
R_{100} is the 100% coverage reflectance
N is the applied ink coverage

This equation gives out an estimation of the dot gain value but it is not very accurate. In the proposed method, a linear regression algorithms have been combined with YNSN model to accurately calculate the real dot gain value. The reflectance of Neugebauer Primary Colours are measured from the test chart then fed into the YNSN model. Different individual ink effective areas are applied to the YNSN model regressively to calculate its reflectance Root Mean Square (RMS) error against the measured value (equation 4). The effective area with the minimum RMS error is the dot gain value of the respective ink. For the CMYK model, four look-up dot gain tables in a range of 0 to 100% are constructed where each look-up table represents one ink channel.

$$Error = \sqrt{\sum_{i=1}^{36} (R_{ai} - R_{bi})^2} \quad (4)$$

Yule-Nielsen Modified Spectral Neugebauer with spectral n-value Model

The traditional Yule Nielsen *n* factor is a single value in the YNSN model but in the practical situation different light wavelengths propagate and reflect in slightly different ways due to both the paper and ink. We conjecture that the single Yule Nielsen *n* factor can only partially represent this phenomenon. The spectral *n*-value approach is proposed to solve this problem by assigning different *n* value to different wavelengths. The spectrometer iSis is capable of sampling 36 samples from 380nm to 730 nm wavelength in a single reflectance measurement, so in this paper 36 *n*- values are used to improve the traditional YNSN single *n* factor. The YNSN model is then changed to the following expression.

$$R_\lambda = [\sum_{i=1}^{N} F_i R_{\lambda,i}^{1/n_i}]^{n_i} \tag{5}$$

Where

n_i is the *n* Yule Nielsen *n* factor for the i^{th} wavelength .

Genetic Algorithm Optimization

Genetic Algorithm is an optimization method inspired by the evolution of populations of a given species which is a perfect algorithm for spectral-based printer characterization [8]. The principle is founded on the notion that an individual in the population is encoded in a particular way (by their DNA) so as to be more or less capable of survival in a given environment. The more capable, the fitter or more likely the individual will be to reproduce and thus transfer useful DNA to later generations. Over time, the population will be comprised of individuals with DNA highly suited to surviving in the environment (as individuals with unsuitable DNA will die out). The process models both reproduction, the exchange of genetic 'material' and random mutations, to ensure that many possible encodings for individuals are explored. Some measure of 'fitness' is usually designed to evaluate the individuals against a particular objective, so that when individuals randomly select pairs and reproduce children: the children will be evaluated along with their parents and only the best candidates will survive (survival of the fittest principle).

In the current work, the genetic algorithm is used to evolve populations over several generations (where an individual's "DNA" encode different parameter sets for F_i and n_i). In this way a population emerges in which a more global optimum (best choice that fits the model to the observed data) results, as compared to that discovered via an exhaustive, individual search (which is more subject to discovering local optima).

The Genetic Algorithm consists of 5 steps (outlined in the following):

1. Initial population
2. Selection
3. Cross Over
4. Mutation
5. Evaluation

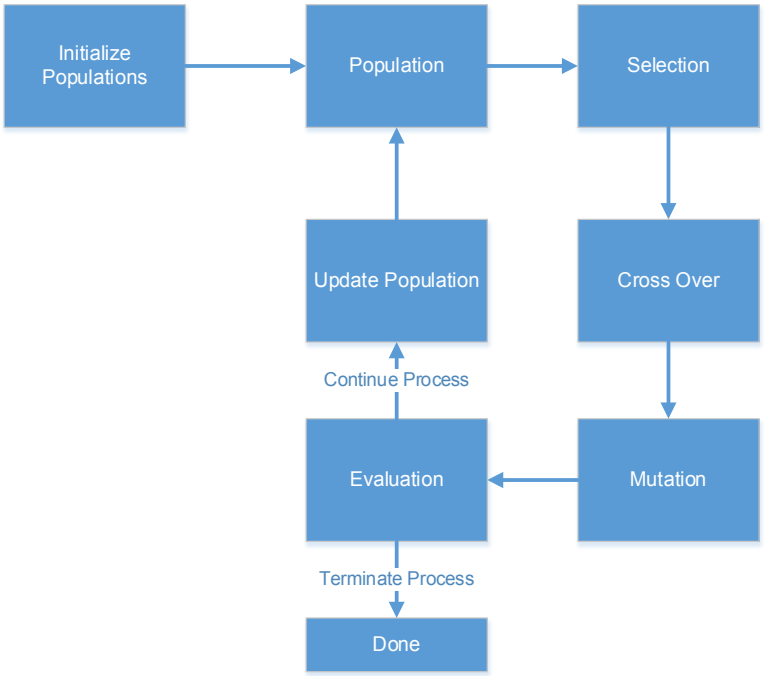

Figure 2: Genetic Algorithm Flow Chart

1. Initialize Population

The dot gain data are arranged into an array with 123 attributes (columns) in an order of Cyan, Magenta, Yellow, and Black with 22 dot gain samples for Cyan, Magenta, Yellow and 21 samples for Black colour in an order from 0 to 100% of the nominal coverage. The 36 spectral *n* factors are attached to the end of array with its initial value set to 1 (specifically, each row in the data set encodes a particular combination of F_i's and n_i's to fit the model to observed data). The reflectance data from test chart were processed by the dot gain extraction algorithm and constructed into array format as mentioned above. After this process, a final array set was obtained and then duplicated itself 50 times to form a population of 50 parameter sets as an initial population for the genetic algorithm.

2. Selection

The 50 population sets are randomly paired into 25 pairs as the parents of the new generation. Each pair of parents will create two children in the next step.

3. Cross Over

The crossover process is inspired from the natural DNA crossover process, in which two pieces of DNA randomly exchange information and become two new DNA sets. In the experiment, two parents uniformly evaluate each data column (parameter) for exchange with a probability of 50%. The crossover method tries to allow for new combinations of solutions (parent parameter sets) that are already known to be effective from the last generation. The 25 pairs of parents create 50 children and those children, similar to the natural produced children, obtained features from both parents.

4. Mutation

In addition to parental features, children also have their own unique features that are different from both parents, for example child's nose is different from both parents. This process is simulated as a Mutation operation. The algorithm randomly selects 50% of data and changes its value randomly in a range of -1 to +1%. We introduce a few constraints to guide this mutation process for the current work:

1. The dot gain has to equal or larger than original coverage
2. 0% and 100% coverage does not have dot gain
3. *n* is in a range from 0 to 100

5. Evaluation

After the mutation, 50 children with unique features are produced. The next step is to evaluate those children together with parent generations and rank them in terms of the minimum RMS error between the calculated results against the measured data. The top 50 individuals will be selected as population for the next process round and rest of them will be discarded (die out). This process is simulating the rule of natural selection that only the individuals with the best features will have chance to survive. The evaluation process is similar to the dot gain effective area calculation, which is applying the dot gain data and *n* value into the YNSN model to calculate the RMS error against the measured data. Each individual candidate contains the CMYK 4 channel dot gain look up table and 36 single *n* values. The inputs of the algorithm are the theoretical ink combination and its measured reflectance. The theoretical ink combinations first are corrected from the 4-channel dot gain look up table. The corrected ink combination and estimated *n* value are then applied to the Yule-Nielsen Modified Spectral Neugebauer with spectral *n*-value model to calculate its reflectance.

Results and Discussion

In the experiment the IT8.7/4 test chart was printed on an offset press with 100lb coated paper in AM screening. PressSign software was used to control the ink keys along with an X-Rite eXact to ensure the densities were within GRACoL specifications; 5 sheets (each sheet has two IT8.7/4 test chart) were measured after 24 hours using the iSis. Those 10 measurements were then processed by the α-trimmed mean filter to find out the best 3 measurements in terms of the number counts of data in the median range. Those 3 measurements were averaged and form a final data for the later process. In the final data there were 1588 unique samples, 1271 of them were used as genetic algorithm training data and rest 317 samples were used as a test set to evaluate how well the optimized model can predict the observed data. There was no overlap between the training data and test data. The performance benchmarks are based on the Delta-E 1976, Delta-E 1994 and Delta-E 2000. The 95% best average and 5% maximum error are recorded. The testing results are in the following tables.

Table 2 Prediction and Measurement Colour Difference of spectral n vs. Single n

	Spectral n		Single n	
	Best 95% Mean	Worst 5% Mean	Best 95% Mean	Worst 5% Mean
ΔE_{ab}	1.0042	2.7912	1.2361	3.5783
ΔE_{94}	0.6920	1.7924	0.8368	2.2391
ΔE_{00}	0.6877	1.8382	0.8191	2.1911

The spectral *n*-value method considered the fact that different wavelengths of light propagate in the paper and ink slight differently. From the experiment, the prediction result of spectral n method is significantly more accurate than the single *n*. The mean of the 5% maximum error in delta-E 1976 is 2.7912 which smaller the human eyes range to distinguish the colour difference. The spectral *n* factor and the comparison of original dot gain curve and genetic algorithm fine-tuned curve are in the figures below.

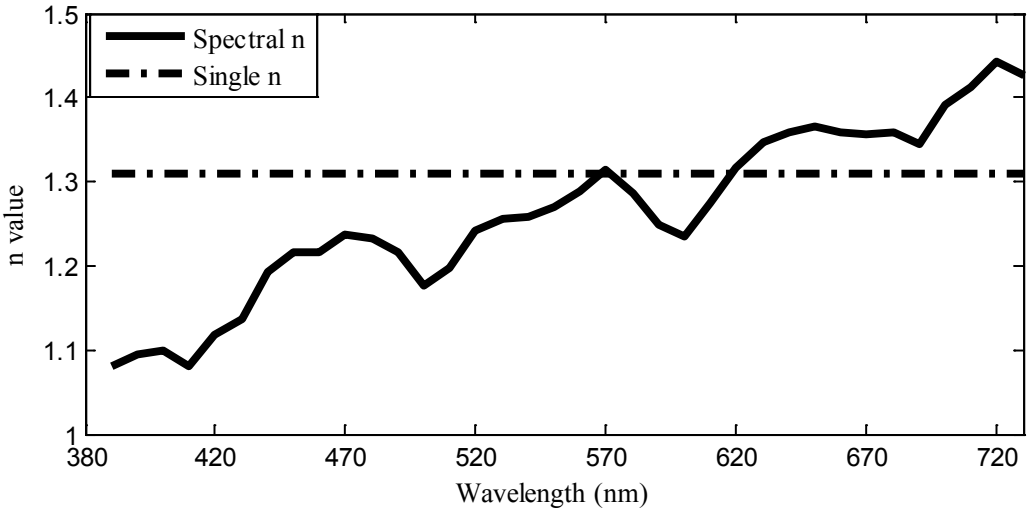

Figure 3 Spectral n values vs. Single n value

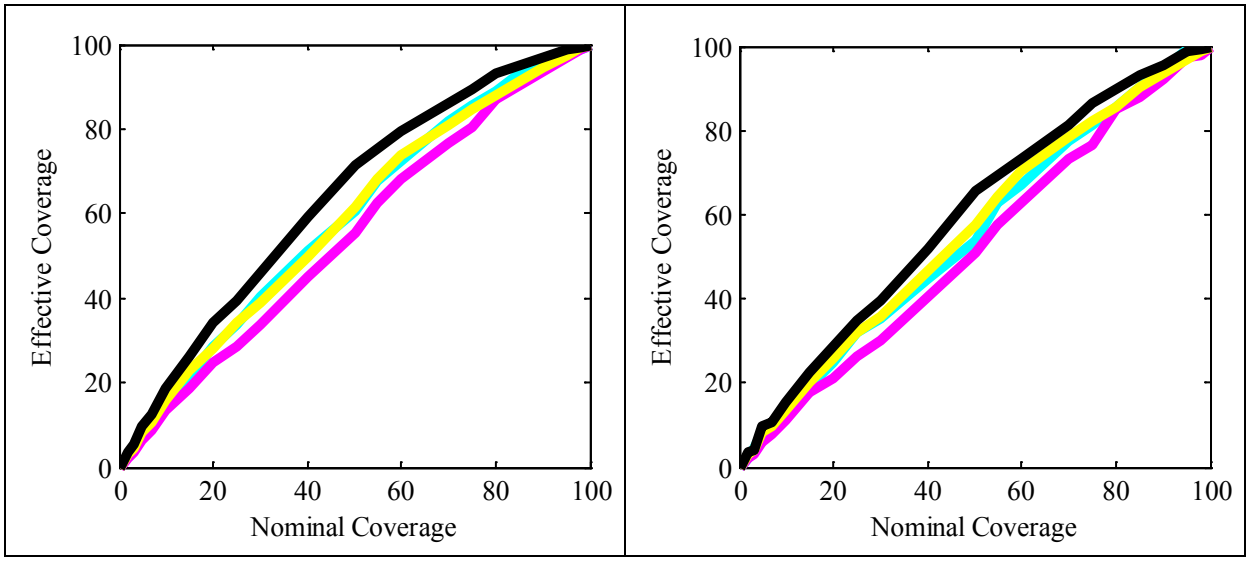

Figure 4 the Original dot gain Curve (left) vs. Genetic Algorithm fine-tuned Curve (right)

Conclusion

This paper presented a method to model dot gain and estimate spectral *n*-value by using genetic algorithm in conjunction with a modified YNSN model. Unlike other algorithms, the genetic algorithm estimates all the parameters in one set to deliver the best representation for the paper-ink-printing model characteristics. The prediction ΔE 5% maximum value in offset press AM screening are smaller than 3, which meets the colour reproduction of printed material requirements. The spectral *n*-value model consistently demonstrates improved ΔE between predicted and observed spectral data, suggesting that different exponents of primary ink reflectances at different spectra might be more suitable in a YNSN-based model to predict the resulting reflectance of particular mixed ink sets. Also, the genetic algorithm proposed has the potential to automatically recover an appropriate model based on measured data from a given ink type and substrate combination, possibly compensating for more subtle effects contributing to dot gain due to ink or substrate properties not explicitly captured by YNSN model.

Acknowledgement

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Biography

Yiming Qian received his Bachelor degree in Electrical Engineering from Ryerson University in 2012. Currently he is an M.A.Sc. graduate student at the department of Electrical and Computer Engineering at Ryerson University. His specialty is Machine Learning and Mathematical Analysis/Modeling. He has experience on colour theory and printing. Also he has the knowledge on spectral prediction model and Human Visual System. He previously worked on color printing related projects.

Printed conductive layer for 3D-RFID-transponder-antennas for future identification applications in smart packaging

Ralf Zichner [1] and Reinhard R. Baumann [1,2]

[1]*Fraunhofer Institute for Electronic Nano Systems ENAS, Department Printed Functionalities, Chemnitz, Germany*
[2]*Chemnitz University of Technology, Institute for Print and Media Technology, Chemnitz, Germany*

Keywords: smart packaging, printed antenna, screen printing, RFID

Abstract

The traditional printing technologies are up to now dedicated to graphic arts. However printing can also be beneficial for applying functional materials beyond color. As an example we are talking about printed conductive inks for manufacturing functional layers which can act as a radio frequency antenna for smart printed packaging. For example standard planar dipole antennas (manufactured employing etching but no printing technologies) for radio frequency identification (RFID) are state of the art and enhance printed packages for logistic applications. A first step has been to demonstrate antennas manufactured by printing technologies. Due to the demand of even more communication quality and reliability of printed antennas new designs and advanced manufacturing methods are under investigation. Therefore we combine the knowledge of printing with experiences of antenna design and electromagnetic wave propagation.

In our paper we focus on a printed conductive layer for 3D-RFID-transponder-antennas for future identification applications in smart packaging. We introduce 5.8 GHz antennas which are printed planar on one side of an item that becomes the inside of a three-dimensional package by folding. The three-dimensional shape of the antenna, resulting from folding, allows directing its radiation mainly to the outside of the package. Following this approach, we achieved an increase of the antenna gain and therefore a significant improvement of the communication quality and reliability. These research results push smart packaging to a higher level of new functionalities and support the development of the internet of things by manufacturing technologies based on printing.

Introduction

Printing is up to now the fundamental technology in the world of graphics. Printing allows the possibility to apply material/inks in a structured way on flexible substrates such as paper. With that it also opens the door for other applications next to graphics. Applications like conductive circuit lines or even antennas can be manufactured by printing of conductive metal based inks [1, 2]. To push printing forward into businesses for radio frequency identification (RFID [3] and Internet of Things[4, 5]) and wireless mobile communication, the scientific areas printing and radio frequency technology have to be combined. This paper reports on research results which benefit of this combination. The aim was to use screen printing to manufacture new RFID transponder antennas on the inside of packages which became three dimensional by folding.

Basics

RFID systems allow wireless transmission of data / signals utilizing two different Radio Frequency (RF) coupling technologies in defined frequency bands. Currently near field applications are based on alternating magnetic fields at e.g. 119 – 135 kHz and 13.56 MHz [6, 7]. The second coupling technique is based on electromagnetic waves at 868 – 928 MHz [8, 9], 2.45 GHz [10, 11] and 5.8 GHz [12]. Both techniques have advantages and disadvantages and therefore they are carefully chosen always depending on the application.

The approach on which we report in this paper focuses on RFID transponder antennas for passive tags working at 5.8 GHz, a legally attested communication frequency with promising prospects of success. This frequency was chosen on the one hand to gain reading distance and on the other hand to improve communication reliability as well as communication quality simultaneously.

State of the art RFID applications employing ID signal transmission via electromagnetic waves utilize planar standard dipole antenna structures, which are manufactured by wet etching. These dipoles regularly show omnidirectional radiation characteristics (see figure 1).

Hence remarkable parts of the emitted radiation will hit the tagged object itself, often consisting of a geometric arrangement of challenging dielectric materials. The interaction of emitted radiation and object consists of absorption, reflection and diffraction effects of the electromagnetic waves causing among others a back-coupling in the antenna and therefore a dysfunction of the functionality and communication reliability of the transponder [13]. To improve the communication quality and reliability of smart systems, transponder antennas have to be developed that feature a radiation characteristic dominantly filling only the space outside the tagged product.

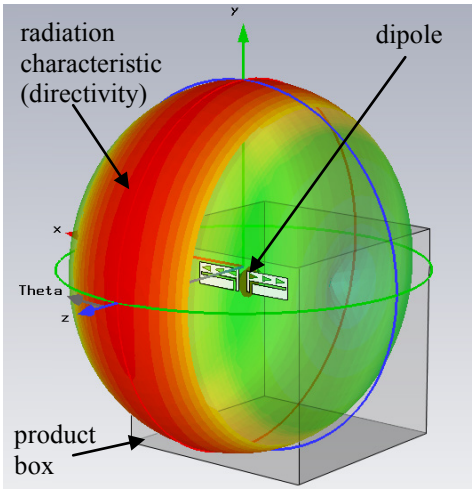

Figure 1. Standard omnidirectional dipole antenna radiation characteristic of a planar RFID antenna [14]

Results

A three dimensional antenna was designed (see. figure 2) in order to implement a radiation characteristic which does not cover the inside of the package. This antenna consists of two antenna arms which are symmetrically and are positioned perpendicular to each other. The antenna design is also optimized for printing. The printed layer has to be done with metal based ink to later receive a high conductive layer of a minimum of $1 \cdot 10^6$ S/m.

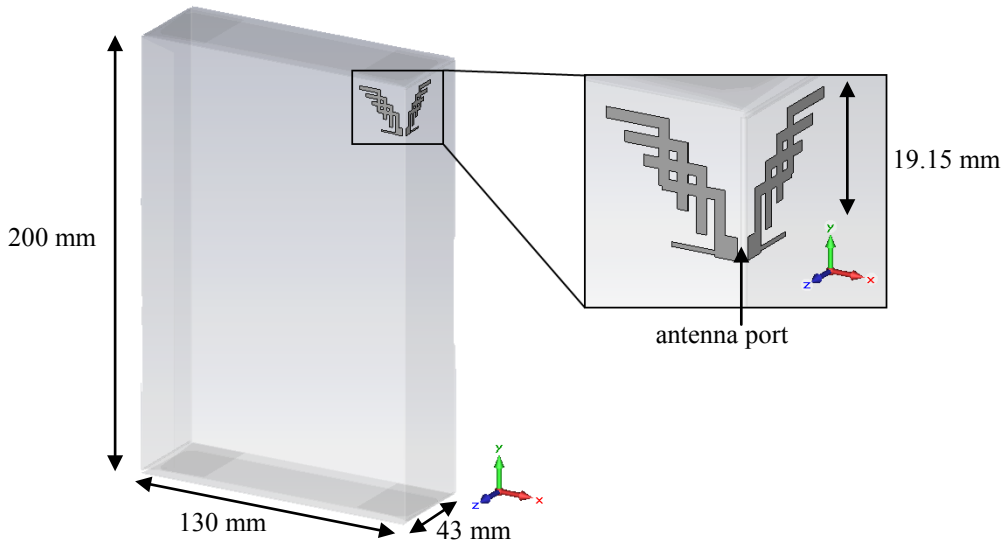

Figure 2. 5.8 GHz 3D antenna design at the inside of a consumer paper based package

The emitted electromagnetic waves of the single antenna elements interfere in our predetermined way causing geometrically intended amplification and extinction. In that way the three-dimensional antenna design defines the radiation propagation in contemplated directions. The simulation results (antenna scattering parameter and antenna radiation characteristics) by applying the "CST Studio Suite – Microwave Studio" simulation tool, are shown in Figure 3-4. The antenna scattering parameter S11 is a frequency depending quality parameter. Less scattering allows high radiation efficiency. It can be seen from this that the antenna reaches the goal resonance frequency of 5.8 GHz. Due to the antenna structure (small finger elements), the antenna shows a large frequency band width of 450 MHz at S11 (-21 dB). This allows a high communication data transfer rate and high

communication reliability. The radiation characteristic of the antenna design (see Figure 4) shows a propagation of the electromagnetic waves in positive and negative y- and z-direction with a realized antenna gain of 3.77 dB.

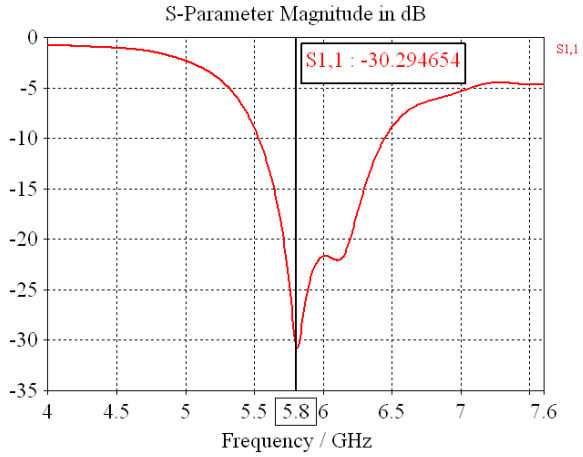

Figure 3. Antenna scattering parameter

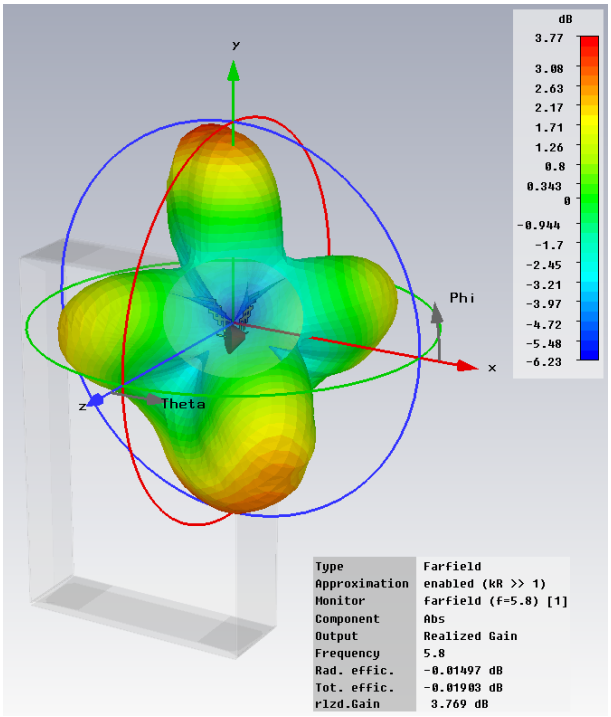

Figure 4. Antenna radiation characteristics

To determine the antenna design and its parameters (scattering parameter, radiation characteristic) by simulation, the manufacturing technology screen printing was employed. For the design of the antenna shape and the simulation of the antenna parameters, the fabrication dependent parameters electrical conductivity (4.5*106 S/m) of a typical silver ink (Sun Chemical CRSN2442) and a dried layer thickness (≈ 4.5 µm) on a standard package paper substrate were applied.

The experimental manufacturing of the antennas was done by flatbed screen printing (printing machine: EKRA E1XL). During the manufacturing process, the whole antenna structure was printed onto a plane package substrate. Afterwards it was dried for 15 minutes at 110 °C under vacuum.

To obtain the final three-dimensional shape of the antenna, the imprinted plain package substrate was folded 90° to the final package shape along a line crossing the conduction pattern (see figure 5).

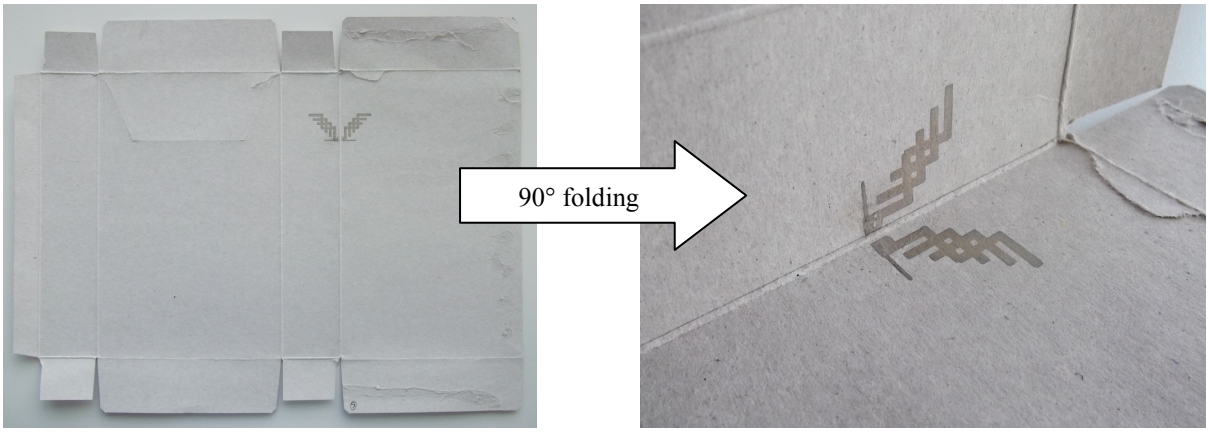

Figure 5. Planar (left) and folded (right) printed antenna

This printed and folded 3D antenna was analyzed in a radio frequency anechoic chamber. The antenna gain was determined and re-imported in the CST Studio environment (see figure 6) for visualization. The radiation characteristic of the determined antenna is comparable to the simulated one. However there are some differences in detail. The measuring shows a lot more antenna radiation lobes. But they radiate also mainly in positive and

negative y- and z-direction. The determined realized antenna gain of 3.69 dB is close to the simulation result. The simulated antenna performance could be confirmed.

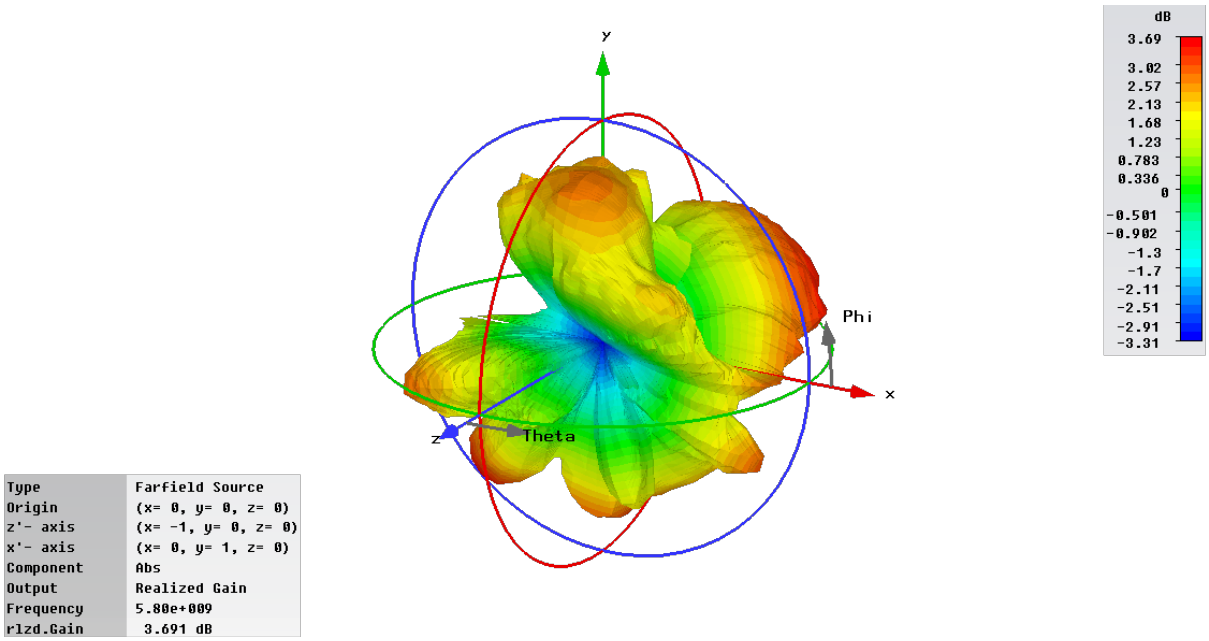

Figure 6. Experimentally determined 3D antenna radiation characteristic

Summary

We have shown that printed 5.8 GHz multidirectional 3D RFID transponder antennas can be designed and adapted in terms of the highest standards of communication reliability and communication quality due to a smart packaging application. Moreover, the manufacturing process of the 3D RFID transponder antenna is a classical screen printing process which is extremely cost-effective in comparison to wet etching manufacturing due to the additive material deposition of the printing technology. Printing is used for packages anyway. An additional printed conductive layer (antenna) can be done easily by adding an additional print work. From the economic point of view, printed antennas are manufactured with least material and without any waste production in comparison to currently used wet etching manufacturing process of conventional antennas. Therefore, the printed antennas are also environmentally friendly.

References

The list of references should be given at the end of the paper, before the Author Biography. References in the text should be numbered by order of appearance in the document, using square brackets, e.g. [1]. The information in the list of references should be given in the following order:

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Author biography

Ralf Zichner holds a Diploma in Electrical Engineering. From 2007 to 2008 he worked as a research assistant at the department for High Frequency Technology and Photonics and at the department of Digital Printing and Imaging Technology, both Chemnitz University of Technology. In 2009 he moved to the department Printed Functionalities of the Fraunhofer Institute for Electronic Nano Systems ENAS, Chemnitz, Germany. His research focuses on design, simulation, printing and experimental characterization of Radio-Frequency components.

Characterization and Measurement of Printing Uniformity

Saleh Abdel Motaal
Rochester Institute of Technology

saa1571@rit.edu

Keywords: Printing, Uniformity, Conceptual Framework, Quantitative Model

This work explores the topic of printing uniformity with focus on the measurement and characterization of the uniformity for quality applications. A new cohesive device- and process-independent conceptual framework and a corresponding quantitative model are proposed. In the scope of this work, printing uniformity of a printing system is defined by its printed ink film thickness consistency, spatially, throughout the printing plane, and temporally, between sheets and runs. Ink film thickness is quantified using CIELAB and ISO visual density.

Extensive review of the pertinent literature including standards and specifications revealed inconsistencies in concepts and metrics, as well as gaps in key aspects, i.e. spatial uniformity. Inconsistencies across the literature were resolved through the refinement and interlinking of key concepts across the spatial and temporal domains.

The proposed printing uniformity framework divides the subject down into dimensions (accuracy and precision), constructs (run and region), and indicators (inaccuracy and imprecision). The framework serves as the basis for the proposed quantitative model, which includes metrics for each indicator, i.e., run and region metrics for inaccuracy, imprecision, unevenness and unrepeatability.

Press testing was conducted in an attempt based on the defined indicators to help with the verification and improvement of the framework and quantitative model. A methodology was designed to allow for multiple press formats and printing processes. Five pressruns were conducted on conventional offset lithographic and electrophotographic presses. Spectral data was measured for 283 sheets with 454 target blocks and a total of 975,328 patches (35,111,808 spectral reflectance data points).

The data was visualized using interactive 3D surface plots representing the uniformity profile for sheets. The metrics and other statistics were visualized using 2D plots optimized for documentation purposes. A special single-color test target was used to Sample the ink film thickness along the spatial and temporal domains. The target is designed for automated spectrophotometric measurement and was optimized to different press formats, i.e., multiple blocks for larger presses and alignment of patches with ink zones where applicable.

Evaluation of the collected data was divided into two stages, i.e., analysis and comparison. Analyses were conducted independently for each test case. Manual assessment of 3D uniformity profiles identified patterns, which allowed for iterative application and refinements to the model for predicting these patterns. Comparisons were made between various printing units on a single press as well as between two presses of the same format. Objective comparison between the units yielded findings similar to previous studies, i.e., circumferential bias in some conventional offset lithography.

Hybrid System for Correcting Non-uniformity in Viewing Booth for the Photographic-Arts and Printing Industry

Nawar Mahfooth[1], Matthew Kyan[2]
[1] *Smartia Printing Technologies Inc., Canada*
[2]*Ryerson University, Canada*
nawar@smartia.ca, *mkyan@ee.ryerson.ca*

Keywords: viewing booth, light uniformity, digital projector, soft proofing, artwork reproduction

Abstract

Viewing booths are illumination stations used for viewing hard copy images such as printed posters and photographic images. Typically, a viewing booth consists of a back-plate against which a hard copy image is placed for viewing, while an overhead lighting source, such as fluorescent lamp, is used to illuminate the hard copy. These viewing booths have found extensive use for visual colour judgment, evaluation of colour deviation, colour-matching applications, and soft-proofing. However, one limitation of such viewing booths is non-uniform (uneven) illumination provided by the fluorescent lamp, which makes accurate colour judgment of the whole printed image a difficult task. As such, there is an enormous need in the graphic art industry for viewing booths that can improve existing systems by providing significantly uniform light intensity across the image that is being displayed in the booth. In this paper, we propose a method that provides enhanced viewing conditions to current viewing booths by correcting the overall uniformity of light distributed inside the booth. Our proposed system compensates for viewing booth illumination using an inexpensive camera and a Liquid Crystal Display (LCD) projector in order to control the amount of light at each pixel individually. This allows for active control over the distribution of light across each point in the viewing surface while positioning the projector perpendicularly on the back-plate of the viewing booth. A digital camera was used to capture the luminous intensity across the viewing booth using High Dynamic Range (HDR) imaging techniques. The captured luminosity profile is used to compensate for the non-uniformity in the viewing booth and automatically adapt the projected image in order to obtain a uniform lighting condition. To test our solution, an RGB test target was placed in two different locations in the viewing booth with and without the compensation light from the projector. For each case, an RGB image was captured using a digital camera. The mean DeltaE in the RGB colour space between the images in two different locations before the compensation was 26.34 while this DeltaE was reduced to 5.23 after the compensation by the projector. Results indicate that using the projector to compensate for the viewing booth reduced the mean DeltaE by 80%. This improvement in uniformity is considered a key factor for measuring/capturing color accurately as well as visual judgment of printed samples and textures.

Introduction

To be able to match two colours and/or judge if two colours have the same appearance, the illumination applied to both colours should be the same because slight changes in illumination result in changes in the perceived colour. This can include changes in luminance level (dark to bright) as well as the changes in the chrominance of the illumination. Luminance changes are very common in everyday life: for instance, a bright sunny day versus a dark overcast day where objects tend to appear very bright and colourful on sunny day and somewhat subdued on an overcast day. For example, if one wants to compare two images, the two images have to be viewed in identical viewing conditions where light intensity is the same across the viewing field. In other words, the light should be as uniform as possible at least on the viewed image. Therefore, it is important to control the intensity and its uniformity because changing the intensity of the light changes the perceived colour [1,2]. For that reason, when generating a soft proof, the user often needs to fine-tune the intensity in the viewing booth until a good subjective match occurs between the monitor and the booth. One flaw however is that these expensive viewing booths do not provide uniform lighting conditions as it can be seen from Figure 1. Achieving a workable environment in which to view soft proofs is therefore currently not automated, and consistent results within the viewing booth are rarely possible without manual tweaking. Even in the case of hard proofing, there is a need for

uniform lighting conditions in the viewing booth so that all colours of the image are perceived in the same manner.

Figure 1 Viewing booth by (GTI Graphic Technology, Inc.) for soft proofing

Projection System as a Potential Illuminant

Colour consistency depends heavily on the illumination under which the product is viewed. This includes changes in luminance level (brightest to darkest) or changes in chrominance [1]. Achieving consistent lighting booth (uniformly lit viewing booth) is strongly recommended in order to provide robust evaluation when colours are viewed.

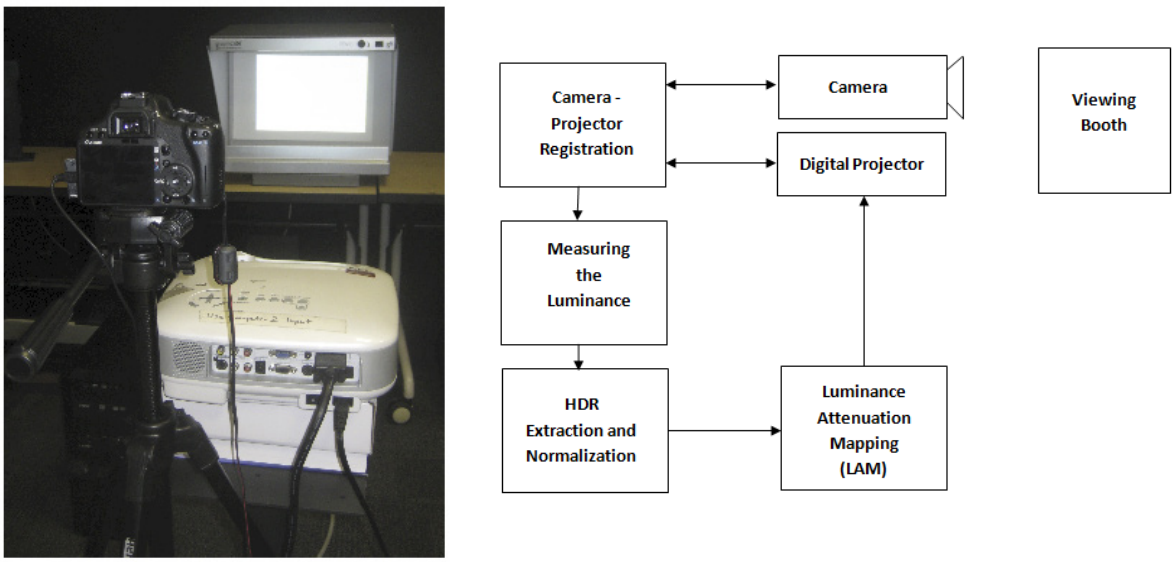
Digital media projectors can be classified as large digital displays, which provide high-resolution images. Conversely, projectors have been used as two-dimensional display devices just like CRT monitors or LCD panels, more typical within larger scale versions of monitors. Projectors, with the aid of a camera can be used for more powerful and valuable applications such as 3-Dimensional (3D) scanning and modeling [3]. While such tasks involve the interpretation of depth and structure based on illumination variations, it is also true that the appearance of any surface or object can change with the illumination [4]. Accurate adjustment of the surface's illumination can be accomplished by pixel-wise control of the colours projected. Digital media projectors were thus investigated for their potential in providing a light source through which projected pixels could be modulating according to non-uniformities measured through a camera.

Viewing booth lighting

Large-scale displays and projection systems are becoming more prevalent and integrated within our daily physical environments. The brightness, contrast, dimensions, and affordability of these displays is increasing, allowing them to be incorporated into immersive display environments that surround the user [5]. The light uniformity in the viewing booth determines the colour appearance, and any deviation from this uniformity will cause distortion in the colour appearance to the viewer (i.e. the same colour patch will appear different in different regions of the booth). In this work, a projector is considered as a substitute/complementary lighting source for the viewing booth. As mentioned earlier, non-uniform illumination provided by the fluorescent lamp in a viewing booth makes accurate colour judgment of the whole hard copy image a difficult task [6]. Therefore, there is a need in the industry for viewing booths that can provide significantly uniform light intensity across the surface of the back-plate and ultimately across the hard copy image under inspection.

Experimental setup

The experimental setup in Figure 2 shows a digital projector (NEC VT670 3LCD) as a light source to illuminate the viewing booth while using the camera (Canon Rebel t1i 500D DSLR) as a measuring device using High Dynamic Range (HDR) imaging techniques to measure the luminous of the viewing area.



(a) (b)

Figure 2 (a) The setup of the hybrid system; (b) The block diagram of compensation algorithm

Camera - Projector Registration in the Viewing Booth

The area of interest on the viewing booth is much smaller than the actual size of the projector's image. For that reason, the image of the checkerboard sent to the projector was modified to fit within a predetermined Region Of Interest (ROI) in the booth. The image was sent to the projector and the captured image of the booth is shown in Figure 3.

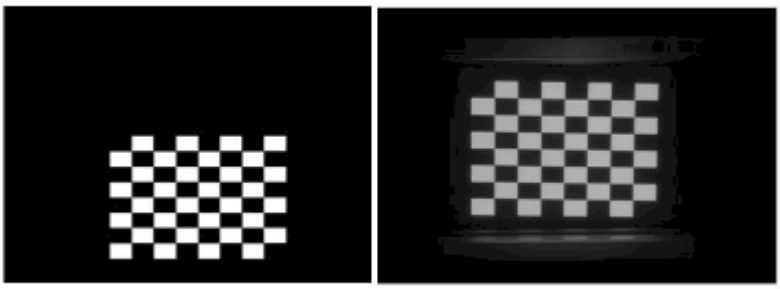


Figure 3 The image sent to the projector for registration (Left) and the captured image of the booth with checkerboard image (Right).

The goal here was to have an accurate geometric registration that maps the input image (captured image) to the base image (image sent to the projector). By selecting four pairs of pixels such that each pair corresponds to the same feature or landmark in the base and input images, a spatial transformation was formed using these pairs to bring the input image into alignment with the base image. This process is also called Camera-Projector Geometric Calibration [7]. Once it was done using the checkerboard image, this registration was valid and used later since both the camera and the projector were not moved.

Determining the Viewing Booth Uniformity

While having the viewing booth light on and the projector light off, it was important to check the uniformity of the light in the viewing booth. The intensity of the viewing booth was set to half and white matte paper was used as background in the booth.

An image was captured using the camera in order to determine the average RGB values when using the viewing booth light with matte paper and the projector turned off. Five images were taken and averaged to reduce noise from the camera. Thus, registration was implemented on the averaged image to obtain the ROI. Based on a 'white' source image (gray scale intensity 255), the image captured by the camera over the ROI was seen to vary between a maximum of 186 to a minimum of 143, with a mean and standard deviation of 177 and 8 respectively. Consequently, there was high variation in the intensity levels across the viewing booth numerically and visually in some cases.

The luminance map was also measured using HDR techniques for the same ROI with the same paper in the same position. HDR was utilized by capturing few images with different exposures and merging them to obtain HDR image from which the luminance was extracted. HDR resulted in a more accurate and real representation of the actual luminance. The resulted measured luminance can be seen in Figure 4 and clearly the luminous across the viewing area is not uniform.

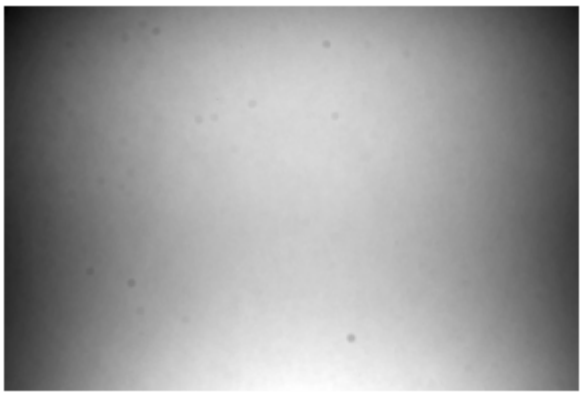


Figure 4 The luminance channel of the viewing booth Measured by the camera before compensation.

The luminance surface was normalized (dividing by the maximum luminance), resulting in a minimum and maximum normalized luminance of 0.55 and 1 respectively. The standard deviation of normalized luminance was calculated and found to be 0.09. This shows the severity in the current lighting booths/stations. The goal is to compensate for this non-uniformity to make a uniform viewing booth using the LCD projector and camera.

Methodology of Creating a Uniform Viewing Booth

The main contribution of this work is to build a hybrid system which uses the viewing booth light as the main light source and only some of the projector's light to compensate for uneven areas, and provide light 'fill' where there is lack of uniformity from the viewing booth light. This hybrid lighting system does not exist in the printing and imaging industry would be beneficial for more robust investigation of colour appearance. We summarize the technique in the following steps:

1. Measuring the Luminance

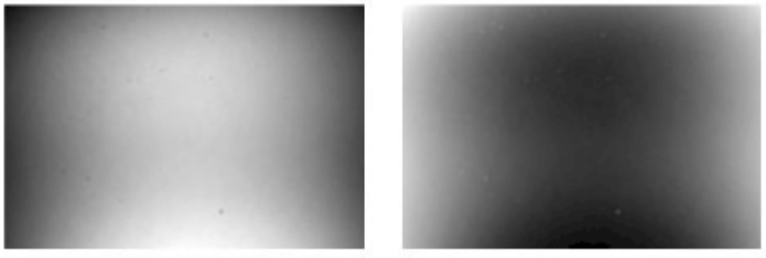
The viewing booth was turned ON while having the projector display full black. The reason is that the projector emits some light when displaying black (this is called black offset). This black offset needed to be taken into consideration while compensating for the light in the viewing booth.

2. HDR Extraction and Normalization

The image registration has been done as it was explained before in order to obtain the luminance of the ROI in the booth when the projector is displaying full black. The luminance was measured by the camera using HDR techniques by taking a total of 19 exposures with 0.4 second as the neutral exposure. After first discarding 10 pixels around the edges (relating to an embedded border used for registration), the normalized luminance profile was calculated (as described earlier), such that the maximum luminance will be equal to 1. The normalized luminance surface is shown in Figure 5(a).

3. Luminance Attenuation Mapping (LAM)

In this step, the goal was to keep the areas of luminance equal to 1 unchanged by sending black pixels to that area and sending more light to the regions requiring light compensation (luminance less than 1). A Luminance Attenuation Map (LAM) [8] was thereby calculated by subtracting 1 from the luminance surface. The resulted LAM is shown in Figure 5(b).



(a) (b)

Figure 5: (a) The luminance of the viewing booth with projector displaying black; (b) The LAM needed for the compensation.

4. Applying LAM

The LAM was then used by the projector's Intensity Transfer Function (ITF) to find the RGB values needed for the projector to compensate the viewing booth light. The LAM has minimum value of 0 (where the light has a maximum luminance of 1) and maximum value of 0.49 (where the lowest luminance occurs). The resulted image from the previous step was applied to fit within the ROI using the same registration settings. The resulted image (shown in Figure 6), was sent to the projector to enhance the booth uniformity.

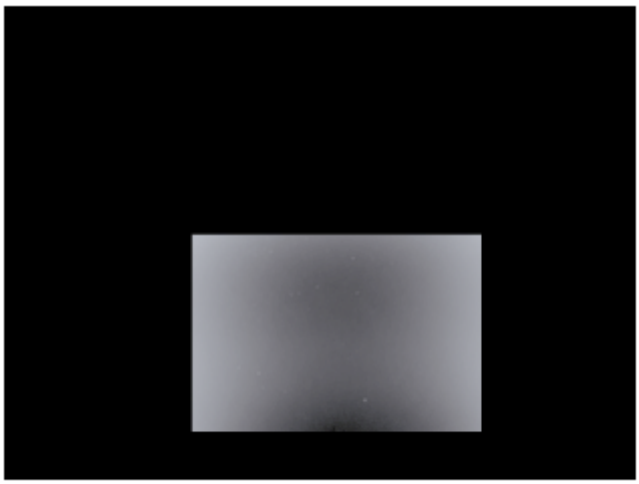


Figure 6: The image sent to the projector to improve the uniformity of the viewing booth.

Results

The uniformity was compared before and after the compensation by measuring the luminance of the ROI after cutting 20 pixels from around the edges. The standard deviation of the measured luminance was reduced from 0.09 to 0.04.

To compare the RGB captured by the camera before and after the compensation, 5 images were taken and averaged to reduce the camera noise sensitivity and were also registered to fit within ROI. After the registration,

20 pixels were cut from the edges and images were converted to gray scaled image and divided by 255 for normalization purposes. The results of before and after the compensation are summarized in Table 1.

Case	Min	Max	Mean	Std
Before	0.56	0.73	0.67	0.04
After	0.66	0.73	0.71	0.01

Table 1 The results of using the projector to enhance the viewing booth

It can be seen from the results in Table 1 that the standard deviation was reduced from 0.032 to 0.01, which means the variation in light intensities within the ROI was reduced to enable more accurate capture of the printed colors on paper.

The above judgments were all based on white paper in the viewing booth to determine its uniformity. On the other hand, it is very important to determine how reliable the new hybrid system is when printed color images are viewed in the viewing booth. The TC9.18 chart shown in Figure 7 was chosen because it contains a wide range of RGB colors.

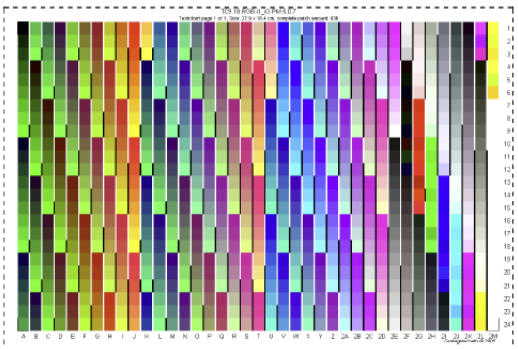


Figure 7 RGB Test chart TC9.18

This test chart was printed using the same matte paper via a custom ICC printer profile that was made for this type of paper. The test chart was attached at the viewing booth in two positions. “Pos1” on the left and “Pos2” on the right (see Figure 8). For each position, there are two cases: without compensation (Booth Only) and with compensation (Booth and Projector). Therefore, in total, there are four different cases as shown in Figure 8.

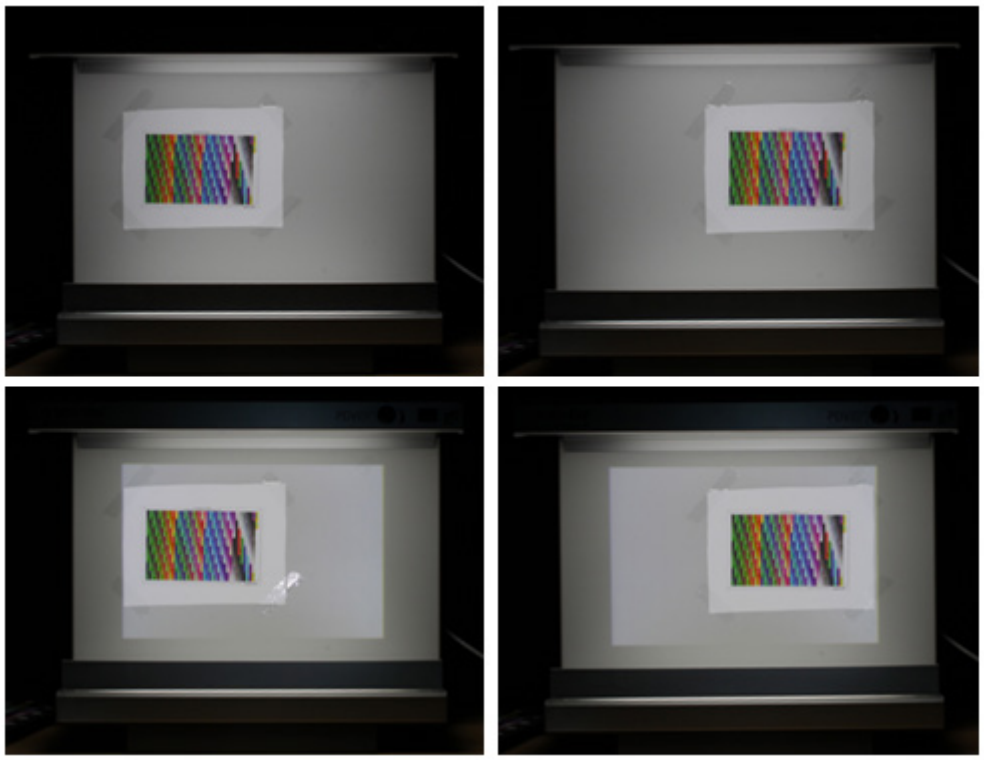


Figure 8: The four cases of evaluating the uniformity performance of the hybrid system. Case#1: Pos1 with booth only (upper left), Case#2: Pos2 with booth only (upper right), Case#3: Pos1 with booth and projector to compensate (bottom left), and Case#4: Pos2 with booth and projector to compensate (bottom right).

For each case of Figure 8, 5 images were taken and averaged to reduce the camera noise. Then, each image was registered in order to automatically extract the test chart image (and associated colour patches) accurately. The DeltaE in RGB colour space was calculated between case#1 and case#2 and it was found to be 26.34. This DeltaE was also calculated between case#3 and case#4 and found to be 5.23, which is the compensated case. This means that the reduction in the standard deviation of the measured luminance from 0.09 to 0.04 reduced the DeltaE within the ROI field of view by 80%. This is a very important achievement when it comes to measuring/capturing colour as well as visual judgment of colours/samples.

To make the projector more like a natural light source rather than a digital display, the projector lens was purposely defocused so that the projected light on the paper is very smooth and actual pixels are not visible anymore. In this case, the pixels of the projected plain white image were not noticeable anymore because all the pixels were blended compared to the focused lens where it is clearly visible to see the pixels on the paper. Defocusing the projector had a big impact visually on how the printed image appears in the viewing booth under different lighting conditions.

Spectral Light Assessment:

Further testing has been done to determine the resulting spectral lighting compared with D50 lighting, to assess whether or not the spectral profile is adversely affected due to the hybrid source. Uniformity measures were tested before and after the compensation according to the ISO requirements. This testing has been done at the GTI facility in New York. Projector model #F35wqxga from Projectiondesign was used for this test since colour temperature was controllable. We also used viewing booth model EVS-2028 shown in Figure 9.

Figure 9 EVS-2028 Viewing Booth by GTI

Same methodology that was used earlier to correct for non-uniform viewing booth was implemented in this experiment. ISO 3664:2009 explains the importance of the evenness of the light intensity across the viewing area since intensity differences cause incorrect evaluation of colour reproduction [9].

The viewing area was divided into 3x3 equal squares resulting to 9 squares in order to measure the light intensity in Lux at the center of each square. This methodology is recommended by ISO to test the uniformity of the viewing booth. In this experiment, SpectriLight III spectrometer (ilt950) from International Light Technologies was used to measure spectral data of light, Colour Rendering Index (CRI), and the intensity in Lux at the center of each square.

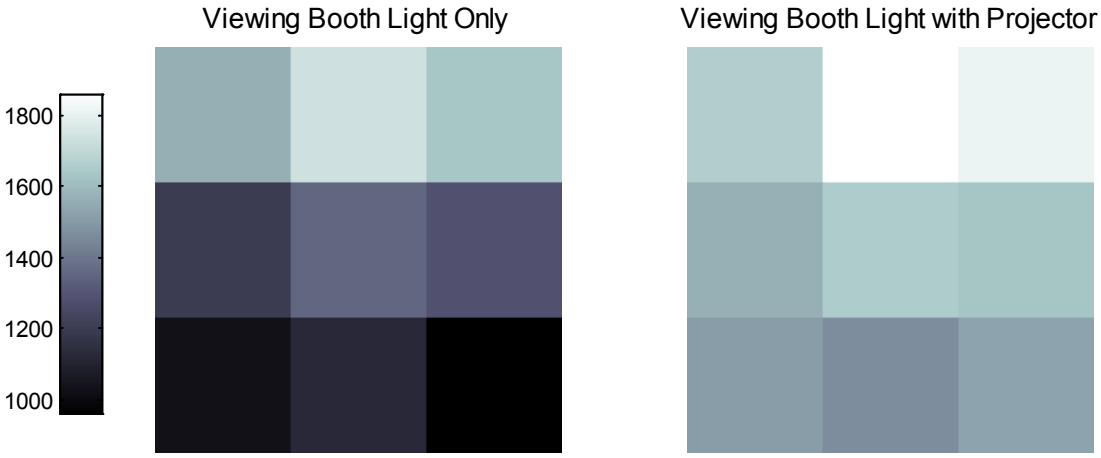


Figure 10 light intensity in Lux on the viewing surface with and without compensation.

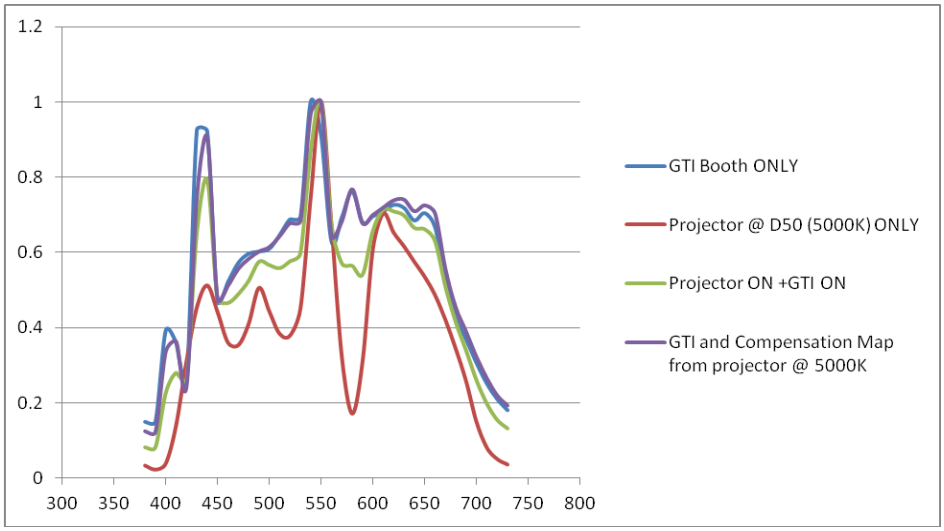


Figure 11 Spectral Power Distribution measured at the center

From Figure 10, it is clear that the projector corrected the non-uniformity of the viewing booth. It can been seen from Figure 11 that the SPD of the D50 booth light when mixed with projector is very similar to the D50 booth light (when used alone), thus the projector did not introduce any appreciable deviation in the spectral signature. This resulted in CRI of 92, which is greater than 90 required by ISO. The results show the hybrid prototype to be acceptable in terms of lighting properties when blending projector lighting with the viewing booth.

Conclusion

A novel method that compensates for the non-uniform illumination in the viewing booth was achieved by using a closed loop system involving a digital camera and projector. As the projector is meant primarily to be a display rather than a light source, we needed to blur its pixels to make it act more like a natural light source. For this reason, the projector was purposely defocused. Using an HDR acquired image of the background illumination in the booth, an algorithm was developed to compensate and modulate additional light from the defocused projector across the ROI. This resulted in a smooth and consistent colour appearance when a printed image was viewed – regardless of its position in the booth. It was concluded that creating the LAM for projector based on the spatial intensity of the white surface provides better uniformity compared with using green channel to create the LAM. We speculate that one possible reason for this is that using all the RGB channels to create the compensating white light will reduce any artefacts coming from black offset when only one channel is used. In the single channel approach, one cannot guarantee that the remaining two channels will not emit any light since light leakage will most certainly exist.

Since Artificial Neural Network (ANN) can be used to accurately model color space transformation such as a printer ICC profile [10], then ANN can be utilized to simulate a soft proofing by utilizing this uniform viewing booth conditions and HDR capture of the printed image will give an accurate perceptual representation of what the printed image will look like in the viewing booth on a calibrated monitor [11]. Another important use could be to automatically capture colours accurately. For instance, this technology could be used to capture artwork for artwork reproduction.

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Biography

Nawar Mahfooth received his M.A.Sc. and B.Eng. degree in Electrical and Computer Engineering from Ryerson University in May 2011 and May 2008 respectively. His M.A.Sc. thesis was heavily based on automated color evaluation of printed materials in a viewing booth for the printing industry. During his graduate study, he developed new technology to balance the light in the viewing booth (patent pending). Since completion of this work, he has been working to establish relationships with industry leaders in this regard. Recently Nawar has been awarded funding to start his own company in order to bring his innovative printing related solutions to the market.

Understanding the New ISO 13655 Measurement Standard in Press and Proofing Applications

Erin Luu, Abhay Sharma

School of Graphic Communications Management, Ryerson University, Toronto

eluu@ryerson.ca and sharma@ryerson.ca

Keywords: Measurement instruments, spectrophotometers, dry back, UV, OBA, fluorescence, ISO 13655

Abstract

There is a revised ISO standard that specifies the illuminant characteristics when using a measuring instrument to measure printed samples. The standard is called *ISO 13655:2009 - Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*.

In this research the instrument measurement modes described by ISO 13655 are examined: M0 – legacy mode, M1 – UV included, M2 – UV excluded, M3 – polarizing mode (for measurement of wet offset press sheets).

In this research the different modes were used to measure papers with and without optical brightening agents (OBAs). Four samples of OBA papers were measured and these show a peak in the blue spectrum due to OBA induced fluorescence. Two proofing papers with no OBAs were also measured, in the case of papers containing no OBAs, M1 and M2 measurements are identical, as expected, as the presence of ultraviolet (UV) light in the illuminant only has an effect on the measurement when the samples contain OBAs.

Many of the metrics in offset printing rely on process control using wet press sheets. It is understood and accepted that these sheets will "dry back" resulting in a lower final density measurement. One of the measurable differences between wet and dry sheets is gloss. Measurement mode M3 using a polarizing filter was tested to see if it can predict the density of a dry sheet from a measurement of a wet sheet as claimed by the instrument manufacturers.

In this research the Konica Minolta FD-7 spectrophotometer was used and the X-Rite i1iSisXL and 530 instruments were also used in this testing. A press run was done using coated and uncoated paper on Ryerson University's Heidelberg PM74, 4-color, offset press.

We conclude that the ISO 13655 standard needs to be widely implemented by instrument manufacturers in order to improve inter-instrument agreement between different makes and models.

Introduction

In the printing industry, one of the major considerations is the ability to deliver accurate and consistent colour to the customer. Colour matching is now often done using instrumentation via a process known as "printing to the numbers". The numbers in this context are usually CIELAB characterization data values that are measured and monitored via use of a measuring instrument. One challenge with instrumentation has been that the ultraviolet (UV) component in the measuring illuminant of different instruments can be different, which causes different instruments to give different readings for the same sample. If the paper or ink exhibit fluorescent behaviour then there are variations between measurement devices when measuring the same press sheet.

The use of optical brightening agents (OBAs) has become very common in paper manufacturing. The OBAs within the paper coating reacts to the UV content in the illuminant, the UV light is absorbed by the OBAs and emitted in the blue part of the spectrum, counteracting the yellow hue naturally found in wood fibre paper, thus making papers appear bluer and brighter. The UV component in a measuring instrument lamp may be small or may not be well defined. When the UV component in a measuring instrument is not well defined, this causes the following problems when measuring samples that exhibit fluorescence:

- there are inter-instrument differences as each measuring device measures the same sample differently
- there are problems with determining a "real" or "absolute" measurement in order that the measured colour will correlate to the colour created when the same sample is viewed in a viewing booth.

Both the above issues can be solved if the amount of UV light in the illumination (measuring instrument and/or viewing booth) is better defined.

Measuring Reflectance

It is not immediately obvious why the UV light should be known (and the same) for all spectrophotometers. Normally there is no requirement for all instruments to have the same spectral emission characteristics. Instruments are designed to have different light sources yet they can still measure the same, this is because when measuring the sample spectrum we are only considering the % reflectance, so there is no requirement for different instruments to have the same illuminant properties.

A spectrophotometer measures the sample's spectrum wavelength by wavelength. The instrument records what percentage of each wavelength is returned by the sample. A light internal to the instrument is used to make this measurement. Generally the actual source used in the instrument is irrelevant and not considered in the calculation of the object spectrum [1]. All that happens during a spectral measurement is that we compute the percentage of the light reflected back at each wavelength. Thus, if we illuminate the sample with 40 units of light and we get back 20 units of light, the reflectance at this wavelength is 50%. An important feature of the spectrum is that it forms a colour description of the object *independent* of the illuminant. In other words the instrument illuminant can be very different in different devices yet they can all report the same spectral reflectance or "colour footprint" for a given sample. (There are limiting conditions due, for example, to low light levels and signal to noise ratio.)

The above description is correct and works well for most situations, however in the case of UV light and OBAs the above theoretical explanation breaks down and we see that the measured spectrum instead of being independent of the illuminant actually starts to be *dependent* on the instrument's illuminant.

The UV in a measuring instrument represents the classic case of the observer causing an effect in the experiment that they are trying to observe because the light used to determine the % reflectance is itself influencing the measurement. In the case of samples containing OBAs, UV from the measuring light is absorbed and emitted in the blue part of the spectrum, so we are no longer simply measuring the % reflectance because the light used to probe the characteristics of the sample is changing the sample's characteristics. When OBAs are present then the % reflectance will change with the amount of UV in the measuring instrument and different instruments from different manufacturers will compute different spectral data for the same sample. Of course if the sample contains no OBAs then everything works according to theory and we can mathematically determine the ratio of incident to reflected light and correctly compute the % reflectance at all wavelengths.

In other words it is easy to see that the reported colour for a sample will be different based on the UV content emitted by the measuring instrument. So to deal with the issue of UV induced fluorescence we must specify the illuminant characteristics, and when that is done we see closer inter-instrument agreement.

X-Rite NetProfiler 3

There is the need for better inter-instrument agreement because a range of physical devices are used in printing. A device may be inline (Xerox iGen4), or in an offset press-side scanning system (X-Rite IntelliTrax), press operators may use handheld spot instruments, or the colour management professional may employ a chart reading device (Barbieri Spectro Swing or X-Rite i1i0). When there are so many different devices used, it is imperative that different devices provide similar readings for the same sample. In order to improve inter-instrument agreement we need to clarify the description of UV in measuring instruments. One way to deal with instrumental differences is to construct a device mapping solution, a commercial example may be X-Rite NetProfiler 3, which seeks to align instruments via a device "profile".

ISO 13655 and M0, M1, M2, M3

The problem to date has been that the UV component in the measuring instrument was not specified and while the illuminant should theoretically not affect the measurement, we have seen that in the case of OBAs it does. An ISO standard – ISO 13655 - has recently been revised and the new revision provides much more clarity for the illuminant and measurement modes.

ISO 13655 was originally published in 1996 and revised in 2009. The new version is called *ISO 13655:2009 - Graphic technology — Spectral measurement and colorimetric computation for graphic arts images [2]*. The new version of the standard now defines four measurement modes - M0, M1, M2 and M3. Suppliers have

produced documents that seek to educate their customers on implementation and relevance of this revised ISO standard [3,4] and a respected blog site has reviewed the Konica-Minolta FD-7 instrument that offers all modes M0-M3 [5].

The new ISO stipulated instrument measurement modes are:

- M0 – legacy mode (based on Illuminant A - tungsten bulb found in older devices)
- M1 – D50 mode
- M2 – UV-cut mode
- M3 – polarizing mode (for measurement of wet offset press sheets).

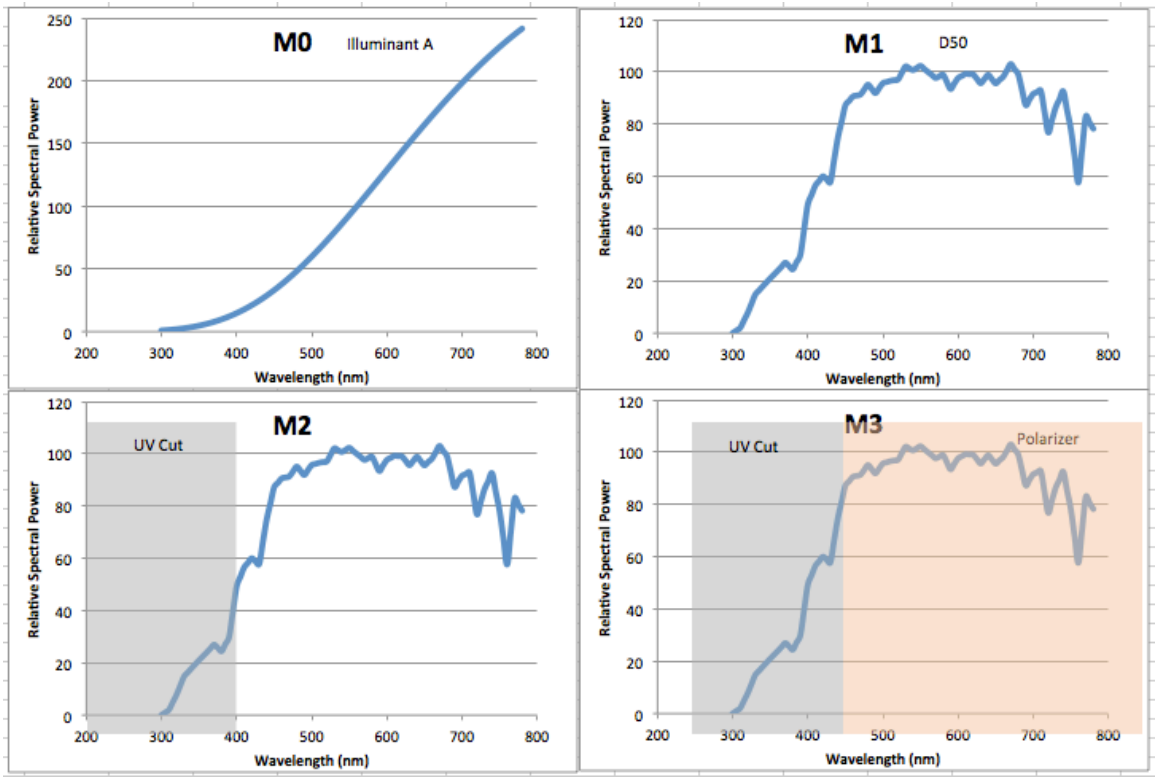

Figure 1: The 4 measurement modes (M0, M1, M2, M3) stipulated in ISO 13655:2009.

M0 is known as the legacy mode and is a standard that expresses the majority of measuring instruments used in the field today. It is directed to instruments that use an unfiltered gas-filled tungsten lamp to illuminate the sample being measured. Prior to LED based devices (e.g. X-Rite i1iSis), the tungsten bulb based device was the primary type of device in the market. We remind the reader that a CIE Illuminant such as Illuminant A is simply an approved spectral graph and not a real physical bulb of any sort, so in practice we say that we would expect that "the light contained within the instrument should have a correlated colour temperature of 2856K". It should be noted that in this mode, the light is neither UV filtered nor polarized, and also the UV component can be very weak, Figure 1.

An M0 instrument can safely be used for process control applications where it is adequate to make repeatable measurements, it can be used in situations where it is not necessary to know the "absolute" measurement value, and there is no exchange of information or correlation with other measurement scenarios. An M0 instrument may not read the same as another instrument that is measuring the same sample, but an M0 instrument is expected to read the same day after day. We would say that a M0 instrument is repeatable or consistent, but not necessarily accurate. (There is the special case of no OBAs, in this instance it is true that measurements performed under M0 should be completely accurate.)

M1 is also known as the "D50 mode" or "UV included mode". A major difference (and improvement) over earlier configurations is that the amount of energy in the UV and visible wavelengths is now specified. The light source in the instrument must match CIE Illuminant D50. Again it is well known that D50 is simply a spectral power distribution curve and there may be different ways to elicit a D50 response. ISO 13655 allows for different methods to achieve conformance to the M1 illumination condition and whichever method a supplier

chooses, "…the instrument manufacturer should supply a representative spectral power distribution of the measurement source…." D50 is one of the standard viewing booth modes, D50 is the basis for the Profile Connection Space in the ICC architecture, all of which make M1 the most desirable mode for today's colour measurement and colour management systems. We hope that all supplier systems are soon updated to meet this revised international standard.

M2 is defined as a "UV-cut" mode. ISO 13655 states that "….to exclude variations in measurement results between instruments due to fluorescence of optical brightening agents….. the spectral power distribution of the measurement source ….shall only contain substantial radiation power in the wavelength range above 400 nm…." How is this mode used in practice? There will be times when a customer will request a print to be measured using M2 because the lighting used to display the job is expected to be free of UV content. A museum is an example of one of the major places that uses UV-free lighting. In colour management circles OBA induced color shifts were often dealt with by removing UV light from both the measuring system and the viewing conditions. Now with the new standard we have a specific definition for "UV-cut" and the wavelength at which it happens. Note that the rest of the illuminant spectral power distribution for M2 is not specified – it does not have to be, as in this spectral range we are in a situation where the instrument illuminant does not interact with the specimen or change the spectral response in these wavelengths, so it is not necessary to define the spectral power distribution of the source from 400 to 700 nm, and a measuring instrument in this range can simply compute the % reflection via the process described earlier.

M3 is a polarizing mode and consists of UV-cut up until 400 nm and then a polarizing filter is also applied to the remaining wavelengths. As above, the illuminant spectral power distribution from 400-700 nm for M3 is not specified – it does not have to be, as in this spectral range we are in a situation again where the instrument illuminant does not interact with the specimen. The main use of M3 is to limit or completely remove surface reflections. In the offset printing industry, the customer pays for the final dry product. One of the main concerns is that the press sheets come off the press wet and as they dry, the density of the ink drops. The M3 mode can aid printers in cutting the surface gloss from wet inks, and if drying is primarily represented by a change in surface gloss then by removing the gloss we may have a better prediction of the final expected dry density.

Because of the polarizing filter the measured density value using M3, may be different to the density achieved from the other modes. In fact in the data we see that each mode (M0-M3) can produce a very different spectral response and thus any computed metrics (CIELAB, CIEYxy, density) can be different. In order to report measurement data in an unambiguous way, ISO 13655 suggest the following nomenclature "ISO Standard/ measurement mode/white backing (wb) or black backing (bb)/make and model". In our data for example we would therefore quote the following

- ISO 13655 (M0, wb, X-Rite i1iSis)
- ISO 13655 (M3, wb, Konica-Minolta FD-7).

Viewing Booths

The clarification for illuminant in measuring instruments (ISO 13655:2009) is accompanied by a similar clarification in the standard for viewing booths ISO 3664:2009 [6]. Via updated standard ISO 3664:2009, emphasis has turned to requiring a closer simulation of Illuminant D50 thus clarifying the amount of UV illumination in the viewing booth. The new viewing booth standard refers to issues such as excluding stray light and that the walls of the booth should be a type of neutral gray, but in the current context, ISO 3664 has called for tighter tolerances on the quality of the light source to ensure that it closely matches the D50 (M1) curve especially in the UV spectrum [7].

We are at a truly exciting juncture in colour management technology – we have a clear specification for the UV component in both the measuring instrument and the viewing booth, together these are able to deal with the challenges of OBA-induced colour changes.

Polarizing Filters and Density Dry Back

It is generally agreed that a polarization filter can give less difference in density readings between a wet and a dried-back printed sheet [8]. This effect, however, is not always consistent, since ink ''soak-in'' depends upon the constitution of the ink as well as the porosity of the paper. When a wet film of ink is applied to paper, the surface of the ink is fairly smooth. The instrument illuminates the ink surface vertically and views the reflected

light at 45°(or the converse geometry). Thus, the density measured, approaches the true diffuse density of the body of the ink. As the ink dries, the surface becomes rougher and, under normal conditions, the density is lowered due to an increase in surface reflections. The effect of these surface reflections can be substantially reduced by the use of a polarizing filter to give us a better predictor of dry density from wet density readings.

There is considerable debate around the use of polarization filters for density dry back measurements. The use of polarization filters is somewhat controversial, since the effect is not controllable and each situation will produce different results, until now there have been no published standards for the use of polarization filters. The situation was akin to the use of UV light in the instrument, it was not stipulated or clearly defined. ISO 13655 now clarifies the situation for the response of the polarizing filter (and clearly defines the UV component). In this experiment offset press dry back was measured with a polarizing instrument (Konica-Minolta FD-7) and compared to a non-polarizing instrument (X-Rite 530).

Experimental Details

In order to investigate the use of the new ISO 13655 measurement modes a Konica-Minolta FD-7 spectrophotometer was used to measure papers containing OBAs and proofing papers without OBAs. The experiment compared the effects of measuring samples with modes M0, M1, M2 and M3. The spectral reflectance of six different types of paper were measured, four samples contained OBAs and two samples were proofing papers with no OBAs. The same samples were also measured using an X-Rite i1iSis spectrophotometer that provides M0 and M2 modes only. The data between the two were compared for the modes where commonality exists.

In the second part of the experiment, an offset press run was conducted to measure dry-back of ink density for offset inks. In this part of the experiment, a job was run on coated and uncoated paper using Ryerson University's 4-colour Heidelberg PM74 press. The paper used was 100M Condat Supreme Gloss Text (coated) and 70M Willamburg Offset Smooth (uncoated). Hostmann Steinberg Perfexia (PX-V) CMYK process inks were used. The Konica-Minolta FD-7 was used in M3 mode to study the effect of using a polarizing filter in limiting surface gloss and measurement of ink dry-back. Comparator measurements were also made with the X-Rite 530 spectrophotometer.

Results

Data from Konica-Minolta FD-7 Spectrophotometer

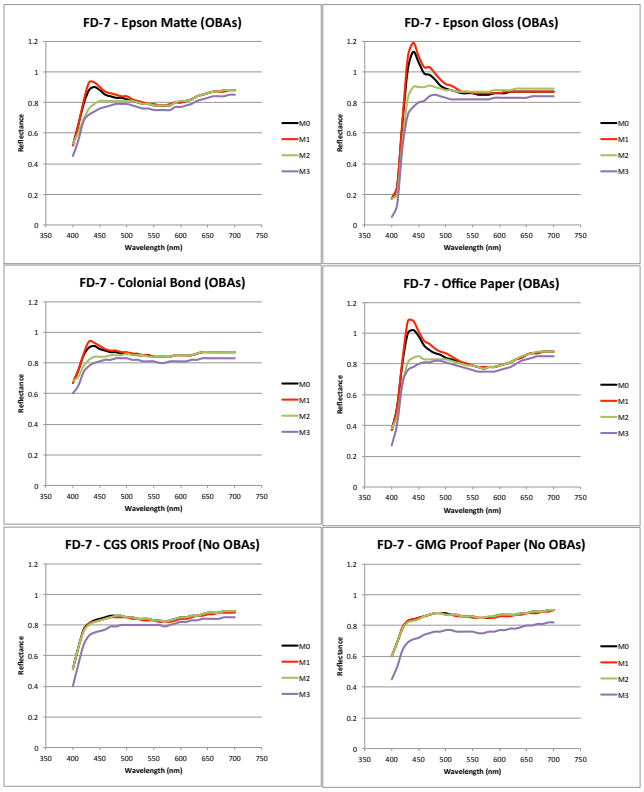

Figure 4: The Konica-Minolta FD-7 spectrophotometer was used to measure the paper white of 4 samples with OBAs (top), and 2 samples with no OBAs (lower).

In Figure 4 we see that the 4 samples measured using the Konica-Minolta FD-7 with OBAs provide different spectral responses for each of the 4 measuring modes (M0, M1, M2, M3) as expected. The M1 mode which includes UV light, shows a surge in the blue spectra from 400-450 nm, as expected. In the lower graphs of Figure 4 we see measurement of the white point of two papers with no OBAs. In these graphs we see overlap of M0, M1, M2 graphs, but that M3 with a polarizing filter creates a "lower" response curve and appears to be a darker colour. This is the expected response as a polarizing filter removes some of the measured light causing it to appear darker (M3).

Data from X-Rite i1iSisXL Spectrophotometer

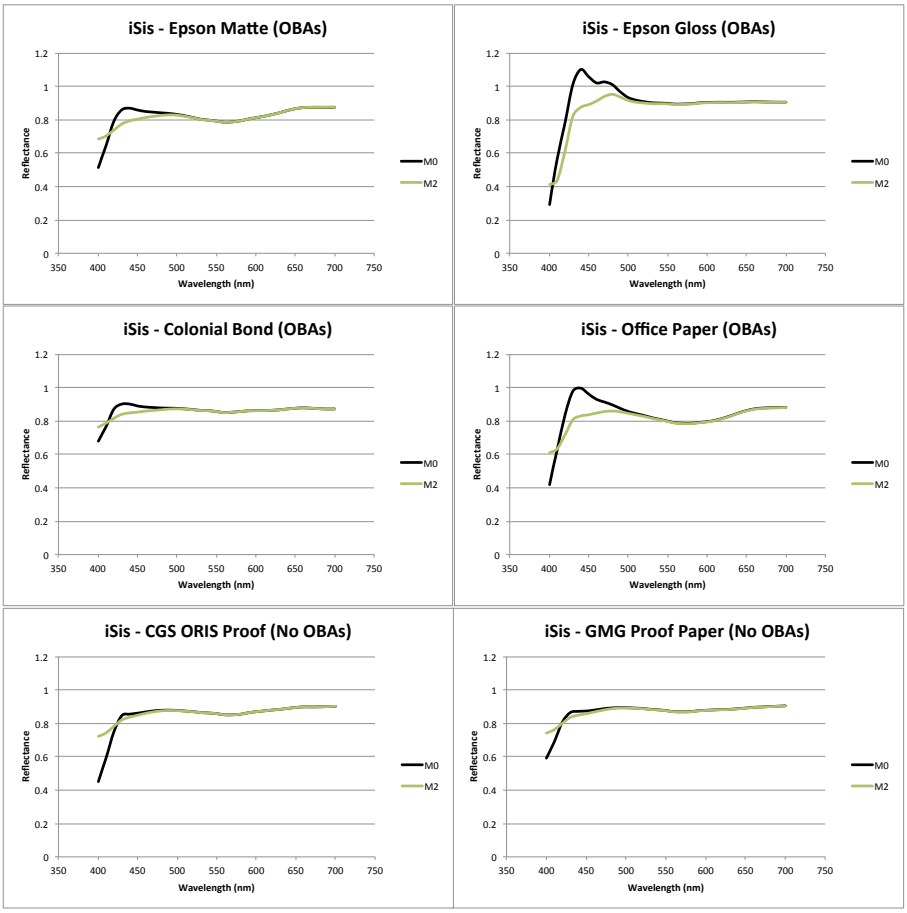

Figure 5: The X-Rite i1iSisXL spectrophotometer was used to measure the paper white of 4 samples with OBAs (top), and 2 samples with no OBAs (lower). The iSis only offers M0 and M2 measurement modes.

In Figure 5 we see that the 4 samples with OBAs (top graphs) measured using the X-Rite i1iSisXL spectrophotometer provide different spectral response for each of the two measuring modes (M0 and M2) as expected. The implication from the top graphs is that the M0 mode implementation in the iSis includes a UV component, which is seen as a boost in the 400-450 nm (blue region) of the measured spectra. In the lower graphs of Figure 5 we see measurement of the white point of two papers with no OBAs. In these graphs we see more similarity between graphs for M0 and M2, as the papers have no OBAs thus both measurement modes produce similar results. Figure 5 helps us understand and "reverse engineer" the X-Rite implementation of M0 measurement mode in the i1iSis (LED) based instrument.

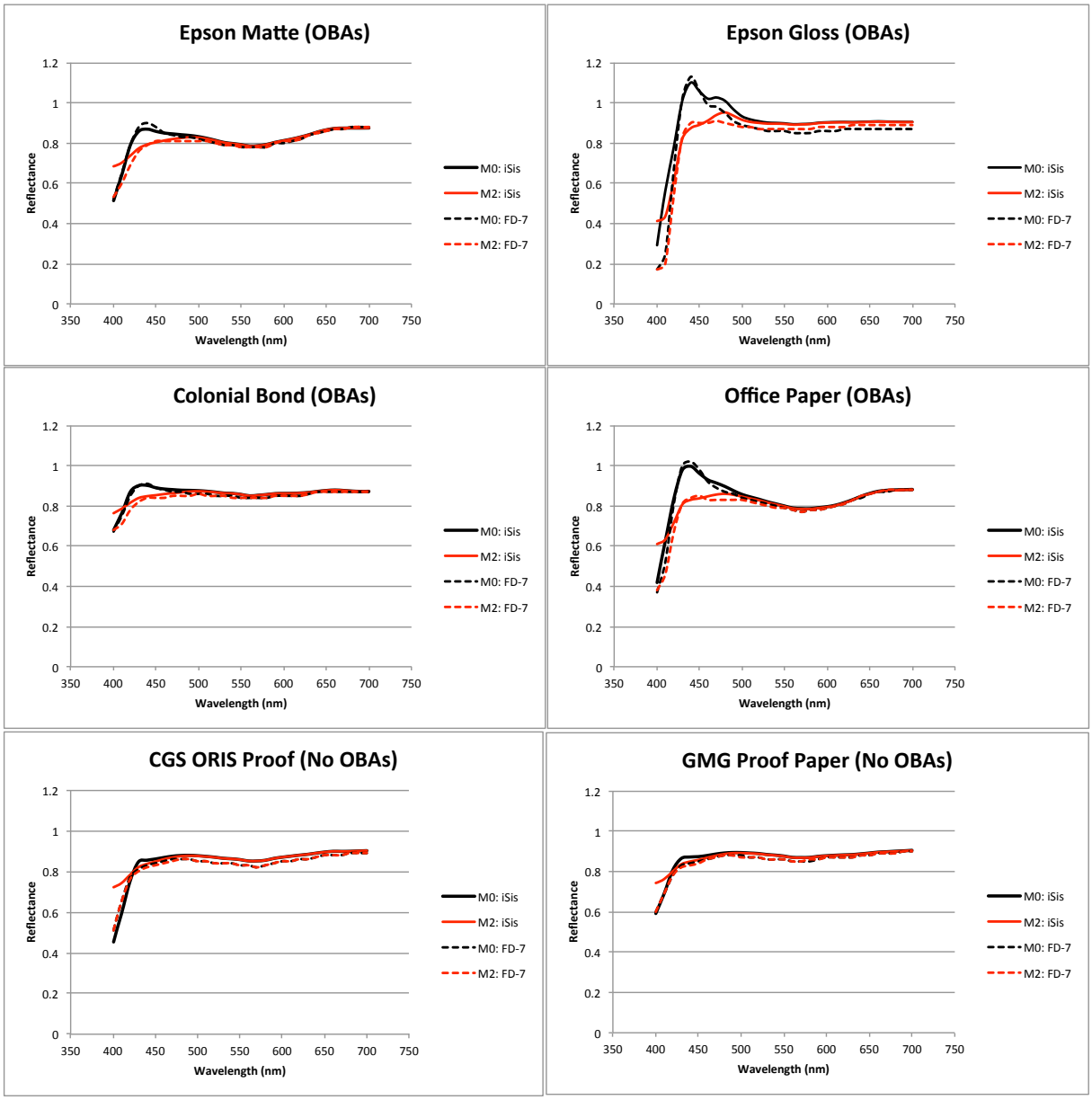

Figure 6: The Konica-Minolta FD-7 and X-Rite i1iSisXL spectrophotometer data is compared for modes common to both instruments – M0 and M2.

The data shown in Figure 6 has been presented earlier. This is data already shown in Figures 4 and 5, but extracted here for easier comparison. The data shows that there is still some difference between the two instruments despite both devices claiming to measure using modes M0 and M2. In order to comment more fully, it would be necessary to compute the difference between these graphs either as a CRI or by converting the spectral data to L*a*b* and then computing a Delta E colour difference. The difference in the spectral graphs contributes to inter-instrument disagreement.

Density change with ink dry back for offset printing

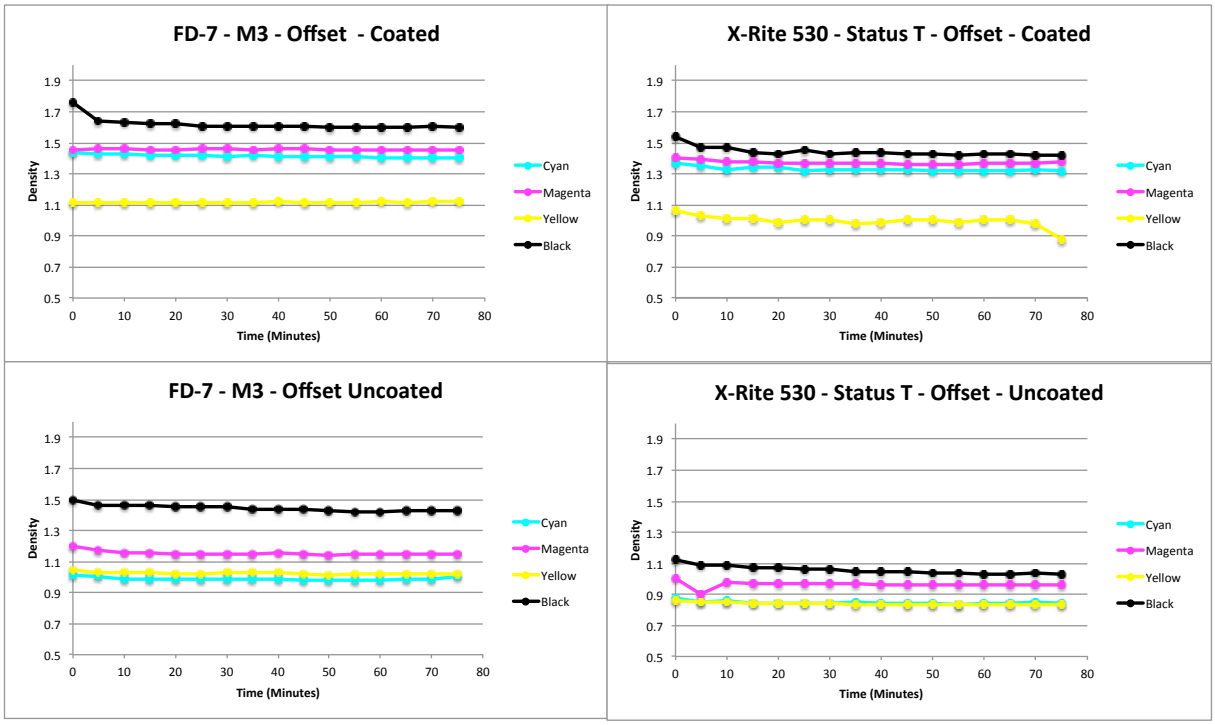

Figure 7: In an offset press run on Heidelberg 4-colour PM74 CMYK ink densities were measured on coated and uncoated stock to evaluate dry-back using the new M3 mode compared to the traditional status T density.

Figure 7 shows results from the dry-back test. The press form was printed on coated stock (100M Condat Supreme Gloss Text) and then the press was stopped and uncoated paper (70M Willamburg Offset Smooth) was loaded. In both instances, during make ready, the press was set to achieve wet target house densities. A press sheet was pulled from the press and measurements were done every 5 minutes for a total elapsed time of 75 minutes. Solid 100% C-M-Y-K patches were measured from a control bar in a single location on the edge of the press sheet. Measurements were taken using the Konica-Minolta FD-7 and then the same patches were used and re-measured using the X-Rite 530 device.

Figure 7 shows that for this paper-ink combination there was in fact not much dry back and the measured density did not drop significantly. The amount of dry-back from this test is not significant, with inks changing by a density of perhaps 0.01 every five-minutes when the sheet was first pulled from the press. The density continues to drop slightly and the rate of the change decreases as the ink begins to dry. From start to finish there was only around a total of 0.1 density difference. The difference between a wet and a completely dry ink film ranged from 0 to 0.16. The black density for both the FD-7 and 530 devices showed the most dry back.

A similar academic project was conducted at Rochester Institute of Technology [9], in that study it was suggested that black and yellow has the least dry-back and magenta was found to have the most. However, the results from this paper-ink combination suggests that black had the most dry-back for both uncoated and coated papers.

The expectation for the Konica-Minolta FD-7 in M3 – polarization mode, was that the initial and final density measurements would be similar. The behaviour of the paper-ink combination in this instance unfortunately did not demonstrate huge dry back, and so it is difficult to draw any sensible conclusions regarding the ability of M3 mode to measure and predict density change due to ink dry back. In general we had hoped to see that when the first reading is made, the polarization filter reduces the surface gloss and makes a reading of a smooth ink film. As the ink dries, the substrate absorbs the ink and there is no longer that smooth surface to measure from, resulting in a different "true" density when the sheet fully dries (Tobias Associates, 2010).

An important result to note is that M3 mode employs a polarization filter, so density measurements in M3 mode are darker than "direct" measurement of density. Some observers suggest that M3 should not be used if trying to obtain perfect colour match because polarization filters will "darken" the measured colours. There is also the

issue of the signal to noise ratio, where the reduced light levels require increased integration time. Some observers suggest that M3 is only effective if a high density of ink is used during printing [10].

Conclusions

The addition of OBAs in substrates introduces many challenges for accurate and consistent colour measurements because different instruments can report different measurements of the same sample. ISO 13655 has helped clarify the UV composition in the instrument configuration, and has defined four measurement modes for the industry – M0, M1, M2, M3.

We note that M0 type instruments are expected to be very repeatable and can therefore continue to be used for process control applications where we need only to measure consistently from day to day and are used where is there is no need to correlate with other external measurements.

We saw that M1 is UV included and akin to D50, and M2 is UV excluded. In this experiment the effect of OBAs in printing paper was clearly demonstrated. If a sample contained OBAs then the spectral response clearly showed a peak in the blue part of the measured spectrum. If a sample contained no OBAs then measurement in M1 (UV included) and M2 (UV excluded) created the same response, as expected.

M3 is a polarization mode and we see that the reported density will often be "darker" when compared to the other modes as some light is removed by the polarization filter. The M3 mode may be used to measure and predict dry back of printing inks. The amount of dry back in the chosen press run was not large, and it was therefore not possible to make convincing conclusions regarding the efficacy of the M3 mode in predicting dry back.

In future work, we would consider instruments from more suppliers, e.g. Techkon and Barbieri. New analysis should also include a calculation of CIELAB values from the spectral data as this expresses any differences can be weighted by the Standard Observer colour matching functions which would "weight" the differences in the graphs according to human perceptual sensitivity. Also if a newer Delta E equation, such as Delta E (2000) was used to compute the colour difference this would continue to express the data in a perceptually relevant manner.

Measuring instruments are supposed to provide a reliable and robust method for colour measurement, unfortunately in the case of UV and OBAs there has been considerable confusion and lack of inter-instrument agreement. The new ISO 13655 standard for instruments and ISO 3664 standard for viewing booths will greatly reduce the colour matching problems currently faced in the field.

It is surprising to see the slow uptake and adoption of ISO 13655 by some instrument manufacturers. There are a number of devices and models in widespread use in North America, these devices are used everyday by prepress, press and brand managers, yet many of these big-name products do not conform to the new standard launched in 2009 – it is now 2013! We appeal to the instrument manufacturers to upgrade or update their instrument portfolio to align with ISO 13655.

Acknowledgements

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Bio

Erin Luu is a senior student in the BTech Graphic Communications Management program, Ryerson University and conducted this research as part of her capstone research project in GRA 634 Printing Processes. Dr Abhay Sharma is a professor in the School of Graphic Communications Management and was supervisor of this project in Winter 2013.

Effect of Gravure Process Variables on Print Defects in Shrink PVC Film

Akshay V. Joshi [1*], Swati Bandyopadhyay [2]

[1] *Department of Printing Engineering, P. V. G's College of Engineering and Technology, Pune, India*

[2] *Department of Printing Engineering, Jadavpur University, Kolkata, India*

** E-mail: joshiakshay1973@gmail.com*

Keywords: Shrink Films, Process Parameters, Gravure Process, Void Area, ANOVA

Abstract

Packaging, as a concept has indisputably undergone a paradigm shift from its time-honored role of a mere protector and a safe transporter to a more aesthetically pleasing and visually convincing mute salesperson. Today the brand owners want to create a niche for their products by differentiating them from their counterparts on crowded super market shelves. The shrink sleeve market, which is majorly based on films like PVC and PETG, is evolving at a rate of 15% per annum. However, printing on these shrink films comes with its challenges. The presence of gels, black specks and other contaminations in these films do not allow the surrounding area to print resulting in print defects such as voids, missing prints and dot skips. Imperfections on these films cannot be completely eliminated. The occurrence of the defects is visually disturbing and result in customer complaints, wastage of material and ultimately product rejection Furthermore, a printer trying to control factors like cylinder, substrate and ink on the press to eliminate print defects is more or less a paradox. Hence, what now remains is to bring the "process parameters" under scanner to minimize these defects and enhance printability. The work focuses on the effect of gravure process parameters on print voids for shrink PVC film. A baseline was first defined and a target was set in order to reduce the print defect up to 50%. A full factorial experimentation was run with four variables viz. line screen, viscosity, press speed and impression roller hardness. The effect of these process variables on print voids were investigated by Analysis of Variance (ANOVA). Hardness and line screen had a major impact on void area. The results revealed that void area decreases with increase in hardness at lower line screen, viscosity and speed. The optimized settings of variables were verified and run five times that showed a consistent behavior. The void area was reduced to 65%.

Introduction

Gravure printing has always been a widely accepted process for printing on shrink films. A key issue that needs to be addressed while printing on these films is the printability. The ink transfer from the gravure cell to the substrate is one of the most vital processes that determine the printability. Hence, it is extremely important to understand this complex activity on a microscopic level. As mentioned earlier, printability can be directly associated with the ink transfer onto the substrate. Printability is evaluated by densitometry, spectrophotometry and the presence of print defects. The occurrences of these defects are random and visually disturbing in the minds of customers, hence it is important to identify the optimal settings for the process variables to enhance the gravure print fidelity. The variables affecting the gravure print quality are nature of substrate, ink viscosity, press speed, pressure, hardness, types of doctor blades, screen ruling etc. [S. Elsayad et al (2002), Bohan et al. (1998), (2000) & Pu jun Deng et al., (2011)]. "Printability could be defined as an achievable print quality resulting from the interaction between the critical properties of the substrate and printing parameters." [Laurent, Girard Leloup, (2002)]. The blank spot area referred to as void area is minimized by higher roller pressure and lower tone, stylus, solvent and speed on Indium Tin Oxide substrate printed by gravure process [Joel Neff, (2009)]. The ink transfer improves at lower viscosity and higher pressure for rough and compressible substrates, while better ink transfer is achieved at higher viscosity and lower speed and pressure on a super-calendered substrate [S. Elsayad (2002), Debora R. Jeske (1990), Sangwon Lee and Yang Na, (2010)]. The ink density increases and dot gain reduces with higher screen ruling and angle and lower cell depth [Pu jun Deng et al., (2011) & E.N. Gencoglu (2005)]. The defects on plastic films are observed only with small gravure cells due to lower cell volume and higher viscosity. Furthermore, maximum dot gain values are obtained on Polyester owing to its smoother surface characteristics [Ryszard Sprycha et al., (2007), E.N. Gencoglu (2005)]. At higher nip force and speed, light spots on the print for PET film decreases [Jang-Woo Lee (2008)]. The color drift is

majorly affected by the change in viscosity and blade angle. The adhesion of ink on to the substrate is improved at lower press speed (Jimmy Vainstein, 2005). The hard roller does not affect the nip width irrespective of the pressure applied; minimizing the web speed variation and compensates for the irregularities in rough paper [Eduard Kuesters, (1972)].
The study investigates the effect of gravure process parameters on print voids in shrink PVC film.

Methodology

A monotone layout was designed that comprised of elements such as step wedge, solids, skin tone, logo, surface and reverse text (Fig. 1). The cylinder was electronically engraved at 175 and 200 LPI with 45^0 cell angle. The trials were run on Gravure machine with solvent based vinyl Black ink on 40 microns shrink PVC Cast film. Initially the trials were conducted for 5 days at set press parameters and 25 printed samples of size 250 mm × 460 mm per day were collected to define the baseline and the target was set to minimize it by 50%. The print voids were captured and digitally processed to calculate the void area as shown in Fig. 2. A general full factorial with two replicates (54 runs per replicate) was designed with three levels for viscosity, speed and hardness and two levels for line screen (Table 1). The design of experiment (DOE) was analyzed by analysis of variance (ANOVA), Main and Interaction Plots to identify the significant factors affecting the defects and figure out the optimal settings of the parameters minimizing the void area. The optimal settings were re-run 5 times for verification and consistency.

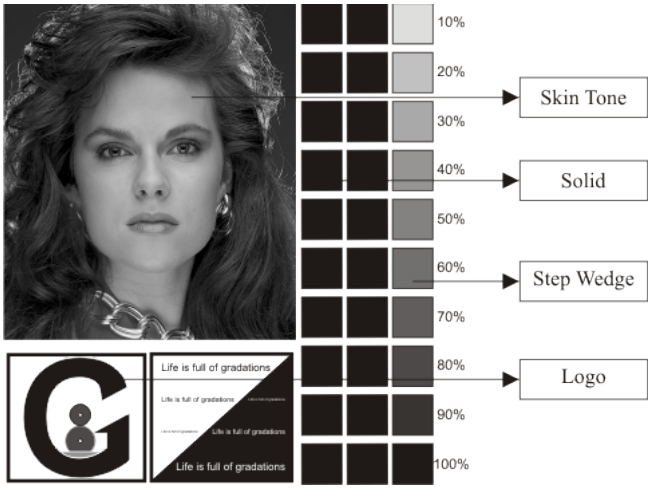

Fig. 1: Elements in the Layout

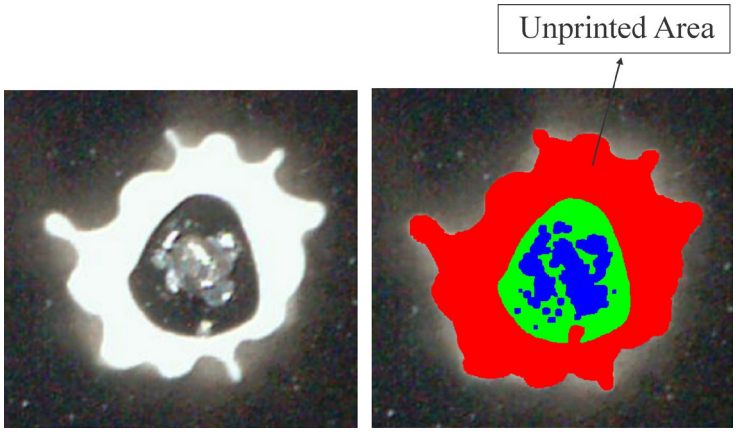

Fig. 2: Raw void image before processing (left) and after processing (right)

Table 1: Process Variables and Levels

S. No.	Variables	Unit	Levels		
			Low	Mid	High
1	Line Screen	LPI	175	-	200
2	Viscosity	sec.	17	19	21
3	Speed	m/min.	80	100	120
4	Hardness	Shore A	60	70	80

Measurement System Analysis

In order to ensure that the data collected through the measuring systems are effective, the measurement system analysis was performed to check the errors and the variations involved in the data. This includes repeatability and reproducibility errors. Gage R&R tool in Minitab is used to determine what portion of the variability in measurements may be due to the measurement system. The evaluation rules suggests that <10% as acceptable variation; 10-30% acceptable depending upon degree of related part size while >30% unacceptable and requires an improvement in the measurement system [Smith G. M (2004)]. The measurement system analysis was done by measuring 10 print voids thrice performed by 3 appraisals.

Table 2: Measurement System Analysis

Source	Std Dev (SD)	Study Var (6 * SD)	% Study Var (%SV)
Total Gage R&R	0.015476	0.09286	3.97
Repeatability	0.008683	0.0521	2.23
Reproducibility	0.012811	0.07687	3.29
Operators	0.008366	0.0502	2.15
Operators*Parts	0.009702	0.05821	2.49
Part-To-Part	0.389471	2.33683	99.92
Total Variation	0.389778	2.33867	100

The analysis showed the percentage study variation for void area as 3.97%. This implies that the measurement system is adequate and acceptable.

Results and Discussion

The production runs were conducted on the PVC film (40 microns thick) for five days on a pilot gravure press. The parameters were set at 175 LPI line screen, 19 sec viscosity, 100 m/min speed, 70 shore hardness and 3.5 kg/cm^2 pressure. The purpose of this exercise was to define a baseline and sample size for the evaluation of void area.

Table 3: Baseline Data for Void Area

Production Run	Mean Void Area/Sheet	Std. Dev.
P1	0.1897	0.0845
P2	0.3078	0.0606
P3	0.2684	0.0612
P4	0.269	0.0652
P5	0.1005	0.0318
Baseline	**0.2271**	**0.0607**

The data collected from the production run showed mean void area per sheet as 0.2271 mm^2 thus considered as the baseline. The target was now set to reduce this area by 50% i.e. 0.1135 mm^2. A 1-Sample t Test showed a power of 0.999 for a sample size of 25 for PVC; hence considered as adequate sample size.

Table 4: Power and Sample Size for Void Area

1-Sample t Test

Testing mean 1 = mean 2 (versus > null)

Calculating power for mean = mean 2 + difference

Alpha = 0.05 Assumed standard deviation = 0.065

Sample Difference	Size	Power
0.11	25	0.999989

A general full factorial design matrix was prepared with 4 individual factors and two replicates (54 runs per replicate).

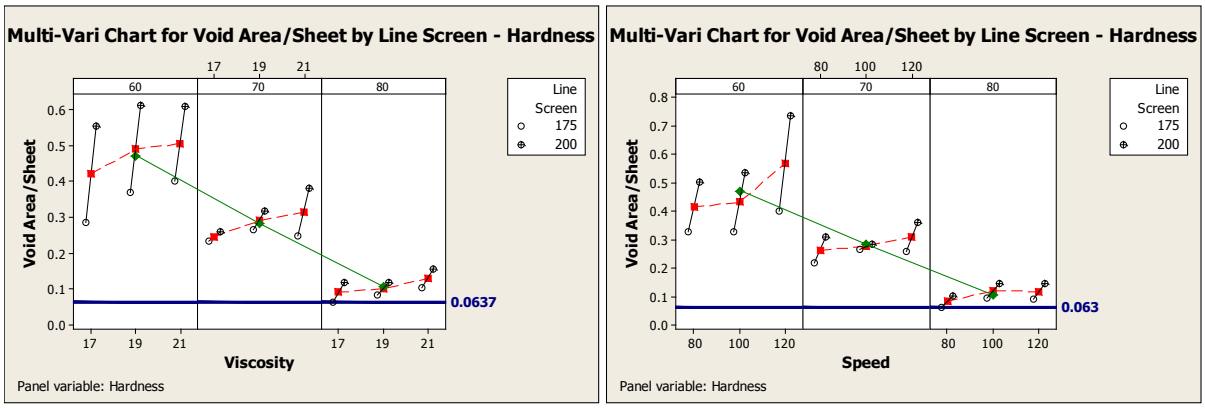

Fig. 3: Void Area/Sheet analysis w .r .t. Viscosity (left) and Speed (right)

The above graphs show a trend of reduction in void area with increase in hardness at lower line screen. The overall minimum void area/sheet is observed at 17 sec viscosity (0.0637) and 80 m/min speed (0.063) for 175 LPI line screen. The interaction between the factors was quantified by performing analysis of variance for the data.

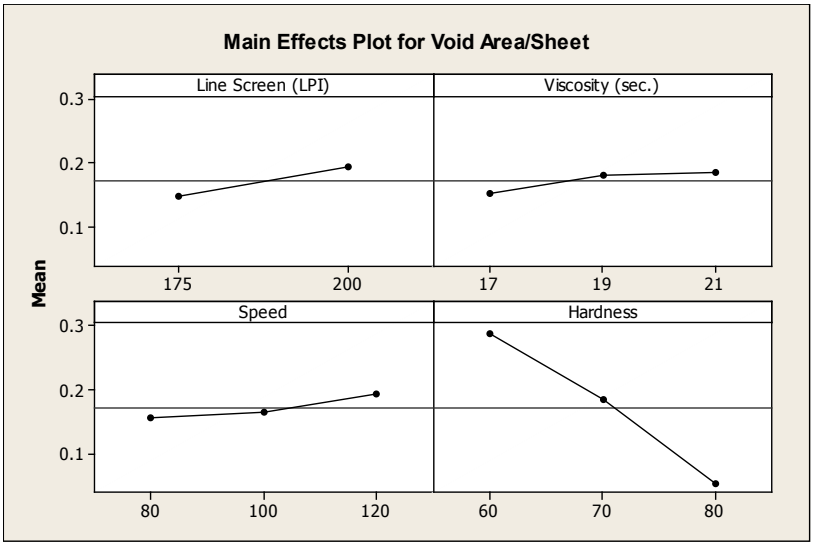

Fig. 4: Effects of Process Parameters on Void Area/Sheet

The main effect plot shows that hardness and line screen as the most influential factors while viscosity and speed as important factors minimizing the void area. The minimum void area/ sheet were achieved at 175 LPI, 17 sec, 80 m/min and 80 shore A hardness. The higher ink volume carrying capacity of a cell at lower line screen resulted in more coverage of the void area. Furthermore, a lower viscosity with higher solvent content allows more ink evacuation from the cell, thus promoting better ink transfer. The hard roller generates maximum amount of nip force. Also at lower speed the dwell time in the nip is more allowing additional contact time between the nip and the substrate. This results in more coverage of ink on the substrates.

Table 5: Estimated Effects and Coefficients for Void Area/Sheet

Term	Coef	SE Coef	T	P
Constant	-5.47998	0.941773	-5.8188	0.000
Line Screen	0.03085	0.00466	6.62016	0.000
Viscosity	0.01345	0.00405	3.32125	0.001
Speed	0.00996	0.003586	2.77671	0.007
Hardness	0.06359	0.013257	4.79661	0.000
Line Screen*Hardness	-0.00037	0.000066	-5.67426	0.000
Speed*Hardness	0.00012	0.000051	-2.32006	0.022

On comparing p- and t- values, the hardness and line screen were found to have a major effect on void area at 95% confidence level.

Table 6: ANOVA Table for Void Area/Sheet

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	6	2.8393	2.8393	0.4732	103.235	0.000000
Line Screen	1	0.3478	0.2009	0.2008	43.827	0.000000
Viscosity	1	0.0299	0.05056	0.0505	11.031	0.001264
Speed	1	0.0694	0.0353	0.0353	7.71	0.006591
Hardness	1	2.2174	0.1055	0.1054	23.007	0.000006
Line Screen*Hardness	1	0.15	0.1476	0.1475	32.197	0.000000
Speed*Hardness	1	0.0246	0.0246	0.0246	5.383	0.022434
Error	97	0.4446	0.4446	0.0045		
Lack of Fit	47	0.2563	0.2563	0.0054	1.447	0.099977
Pure Error	50	0.1884	0.1884	0.0037		
Total	103	3.2839				

Summary of Model

S = 0.0677045 R-Sq = 86.46% R-Sq(adj) = 85.62%

The ANOVA table for Void Area/Sheet indicates that all the main factors are significant as the p-values are below α value of 0.05. The hardness and line screen are the major influential factors in minimizing the void area as indicated by relatively high F-statistic values. The larger F-statistics with $P < 0.05$ from the ANOVA table confirms the significance of all the main and interaction between viscosity, speed and hardness on print voids at 95% confidence level. The high percentage of coefficient of determination (R^2) indicates that 86.46% of the variability could be explained by the model. The high value of adjusted R^2 (85.62%) indicates the significant regression of the model by using four parameters. The higher R^2 (predicted) of 84.36% indicates that the model provides a great predictive ability.

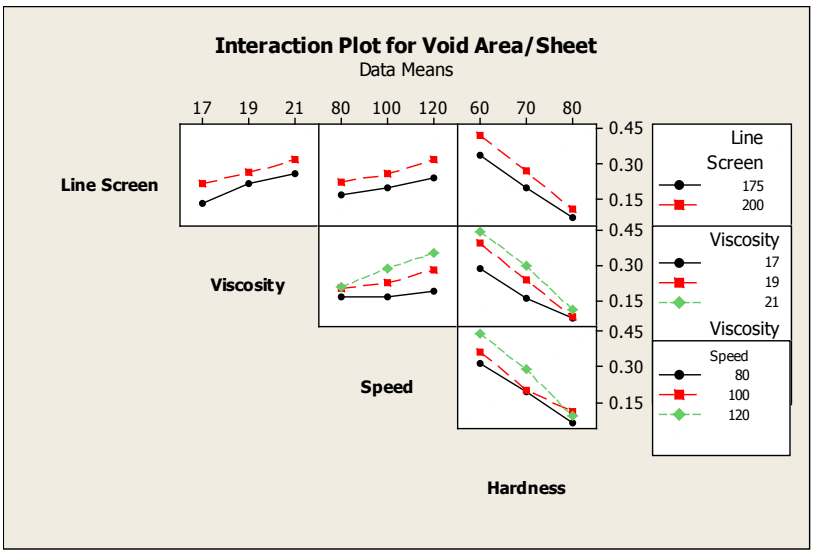

Fig. 5: Interaction Plot of Process parameters on Void Area/Sheet

From the above plot, it is observed that the interaction of Hardness with Line Screen and Speed are significant effect on reduction in void area at the 95% confidence level. The interaction plot shows minimum void area at 175 LPI, 17 sec, 80 m/min and 80 shore A hardness, hence considered as best settings.

Verification and Consistency

The best settings as obtained from the interaction plot was confirmed by conducting a press run and then checked for its consistency by re-running for 5 days (Table 7).

Table 7: Verification and Consistency Runs for Void Area

Trials	Line Screen (LPI)	Viscosity (sec)	Speed (m/min)	Hardness (m/min)	Void Area/ Sheet (mm^2)	Std Dev. Void Area
Verification	175	17	80	80	0.07921	0.0417
Consistency	175	17	80	80	0.07622	0.0569

Both verification and consistency trials confirmed the results and were in close agreement with each other.

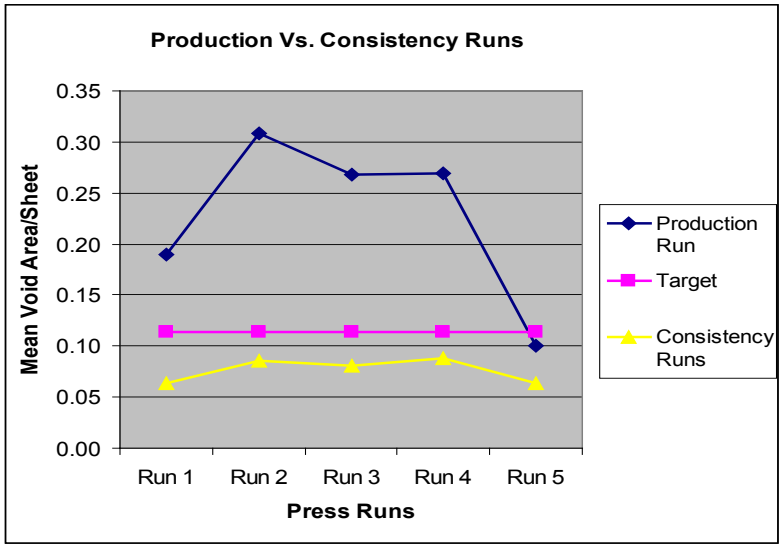

Fig. 6: Production and Consistency Runs

From the above graph, it is clear that void area/sheet for all the consistency runs were well below the set target of 0.1135 mm^2 , thus indicating that there is a significant improvement from production run to consistency runs.

Table 8: Production and Verification Run for Void Area

Trials	Void Area	Std. Dev.
Production Run	0.2271	0.0607
Verification Run	0.07921	0.0417

Also a significant improvement in void area is observed from Production run to Verification run as shown in Table 7. The void area is minimized by 65.12% which is well above the set target.

Conclusion

The work investigates the effect of gravure process variables on print defects. The work focuses on identifying the vital process factors that play an influential role in minimizing the print defects and enhance printability on Cast PVC film. These findings contributed to optimize the process and to spot the best possible combination of press parameters. A general full factorial was designed for process parameters namely, line screen, viscosity, speed and hardness. Main effects, Interactions and ANOVA were used to study the effect of process parameters on void area. The analysis revealed significance of all the main effects with hardness as the most significant factor in minimizing the void area. The two level interactions were also found to be important. This study also found the optimal parameters as 175 LPI, 17 sec, 80 m/min and 80 shore A, minimizing the void area by 65.12% which is well above the set target. The R-square value (86.46%) of the statistical model equation shows a good fit of the model with experimental data. However, the set target of void area below 0.11 mm^2 was achieved for viscosities ranging between 17 to 19 sec, speed ranging between 80 to 120 m/min at 175 LPI line screen and 80 shore A hardness.

Acknowledgement

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Biography

Akshay V. Joshi is a Research Co-ordinator in Printing Engineering Department of P. V. G's College of Engineering and Technology, Pune, India. He completed his Bachelors Degree in Printing Engineering in 1994. After graduation Mr. Akshay Joshi joined UVIFORT Metallizers Limited, a company involved in Flexible Packaging and Converting. He then joined College of Engineering and Technology and completed his Masters Degree in Printing Engineering from Pune University. He has 17 years of experience in teaching Gravure, Flexo and Flexible Packaging subjects and handled research projects in Gravure. He has registered for PhD from Jadavpur University, Kolkata, India.

White base coat CIELAB values for Flexography and Offset packaging printing on non-absorbent substrates

Enn Kerner, CEO Grafitek Estonia, enn@trykitehno.eu

Martti Lemendik, CEO Metaprint Estonia

Keywords: *non-absorbent substrates, white base coat, flexography and offset technology, ISO quality, Process Standard Offset*.

Abstract

In changing printing industry market situation to prepare technology and industry engineers we, as teachers or visiting lectures, shall keep our selves up-to-date on different printing trends. Engineer's qualification and competence, to new production possibilities and trends, must be introduced already during the studies. This whitepaper will introduce key-points of the two printing technologies - flexography and offset packaging printing, how to apply into curriculums topics of white base coat on non-absorbent substrates and standardized quality printing requirements.

White base coat have a vital role for the colour quality management, that printed products can meet ISO12647-x standards requirements and to economical influences of the production self-cost. Non-absorbent substrates are less introduced in engineers studies, due the fact that printing on paper has been the major and successful printing substrate so far. Non-absorbent substrates require different approach then absorbent substrates does. In packaging production, often two or even more printing technologies are meeting.

Problem definition

Due the fact in traditional offset technology the production trend is in direction to reduced print runs and shifting to digital output devices. To promote printing technology to young engineers, we shall point accent between offset and flexography packaging printing technologies on non-absorbent substrates. Packaging printing will keep the printing industry sustainable for longer time from now. Our recent studies showed, that the need of wide mind thinking engineers are expected in all Graphic Arts industries. New engineers entering to labour market are expected already in early stage to have competences to standardize full workflow and production quality. By experience, we are facing in our everyday work, the problem where industry does not have enough staff to manage ISO printing standardizing processes in house. Then the topic is taken on table with standardize body organizations, they inform that to work out new standards takes long time (average ~5 years) and lot of founds. With this whitepaper we show how to assist engineers to make in house process adjustments to match the production to ISO 12647-x standard requirements and how to manage the white base coating on non-absorbent substrate. Today's technology engineers shall have deeper competences than only traditional offset technology (the offset has been mainstream for the printing engineering studies for long period). How to make different technologies to be comparable to ISO12647-2 and 12647-6 standard requirements? How white base coating shall be adjusted to achieve equal primary colours quality? Those questions are less touched in past and present during engineering studies. Common curriculums mostly are based on the offset technology orientation to publication or civil production printing.

Used Terminology

Non-absorbent substrates – all inks and coatings stay on surface and do not penetrate into the printed media volume;

White base coat – thermoplastic white TiO_2 pigmented ink;

Flexographic technology – printing technology where printing form is elastic, printing elements higher relief and impression cylinder is rigid;

Offset technology – printing technology where printing plate is rigid and printing elements are nearly on same surface, non printing elements are water attractive and printing elements are oil attractive, the image is transferred to intermediate elastic surface before it reach printed media;

Solid Area Ink Film Weight – dried or cured printing ink on printed media surface, measured by gr sqm and covering full measured surface area;

ISO standard – ensure that production and services are safe, reliable and of good quality;
Process Standard Offset – document defining for the printing process the tolerances;
Contact Angle Method – angle that is measured through the liquid where liquid interface meets a solid surface;
CIELAB – device independent colour space;
Aim value – by ISO standards defined colorimetric or densitometry value;
Characterization table – in .icc profiles described aim values database;
Surface energy – quantifies the disruption of intermolecular bonds that occur when a surface is created;
Primary colours – Cyan, Magenta, Yellow and Black process printing inks;
Grey balance – colour managed balance between CMY and K;
Black Backing – measurements made using the black surface under the printed media;
Screen roller – ink transfer roller used in flexography printing technology;
Cell count – number of ink cells on the surface of the screen roller;
Theoretical ink volume – amount of ink in side of screen roller cells and is transferred on the surfaces of printed media.

Process development

Non-absorbent substrates for offset and flexographic printing technology

In our works, we compare two similar non-absorbent substrates with similar surface behaviours. From flexography printing Al-foil for the dairy, pet etc. packaging production and from offset printing steel and Al-sheets for the products food, cosmetic etc. can production.

Due time and space limitation this whitepaper will touch major non-absorbent substrates on metal base. Due the complexity of the process database and confidentiality clause, we show only some examples from both printing processes and similar production portfolio. For the more detailed information, please feel free to contact by e-mail: enn@trykitehno.eu

Most flexography printing technology substrates are non-absorbent and only few are based on paper fibres. Common fibre products are combination of cardboard or paper, PE and Al. One biggest segment is liquid packaging products printed on high-speed flexography printing machines. Production of liquid packaging was taken over from offset technology. Take over last only few years, then direct driven print units were introduced in flexography printing technology in the middle of 90-s. Bulk industry products are generally non-absorbent substrates as PE, OPP, BOPP etc. Food and pet food packaging mainly printed on Al-substrate. Most offset printing technology substrates are absorbent, based on paper fibres and only few are based on plastics, Al, steel etc. Common non-absorbent substrates products are for the high-tech advertising and metal-décor production etc.

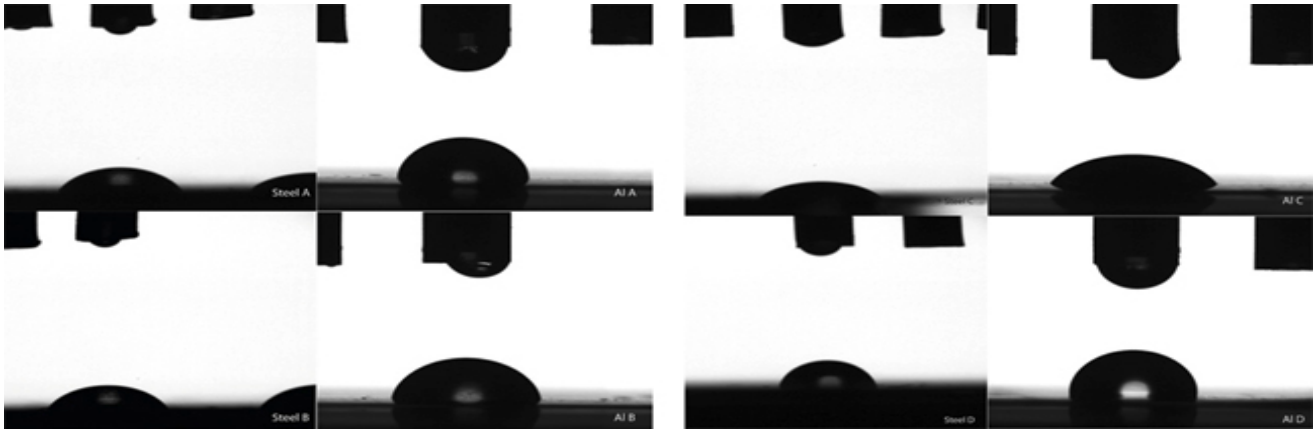


Figure 1. Comparison between steel and Al-foil surfaces.

Due the development of the digital printing and flexography machines direct driven print units, the offset technology has lost some production and today need new and different approach to keep technology sustainable. Increasing offset printing technology on packaging printing field, can support technology sustainable development. Therefor in this whitepaper we introduce how to monitor the white base coat quality on the metal

substrate using metal-décor offset printing as example and comparing it with flexography Al foil printing. Printed media surface characteristics are the base for light reflection and later colours management of the primary colours, see Fig. 1.

Due early mentioned limitation, we analyse only the thermoplastic white base coat on the metal surface. To determine the right surface properties we studied the surface behaviour and surface energy using the high-speed camera and contact angle method see Fig. 1. Knowing surface characteristics we are able to control the white base coat flow properties and lay down quality on the printed media surface. Used laboratory tools KSV Instruments Ltd Cam200 and Surface free energy reporting, see Fig. 2.

Steel A1x150C
"D" water

Time, s	X, mm	T(Angle, °)	CA(L)	CA(R)	CA(M)	Tilt	L, mm	H, mm	Vol µl	A, mm2	Beta	Fit tilt	r(pix)
0	-1,8	0	83,429	83,853	83,641	0,21	2,723	1,152	4,256	10,139	-0,366043	1,524	0,053
1,016	-1,8	0	83,409	83,744	83,577	0,304	2,724	1,152	4,258	10,141	-0,358468	1,162	0,061
2	-1,8	0	83,52	83,723	83,622	0,315	2,723	1,152	4,254	10,135	-0,361084	0,957	0,06
3,016	-1,8	0	82,197	82,778	82,488	-0,696	2,722	1,133	4,147	9,98	-0,341775	1,247	0,065
4	-1,8	0	83,305	83,712	83,508	0,224	2,723	1,151	4,247	10,125	-0,3625	1,544	0,06
					83,3672								

Steel A1x150C
"C" diiodomethane

Time, s	X, mm	T(Angle, °)	CA(L)	CA(R)	CA(M)	Tilt	L, mm	H, mm	Vol µl	A, mm2	Beta	Fit tilt	r(pix)
0	-6,7	0	63,57	66,33	64,95	0	3,456	0,903	4,968	12,301	-4,670325	1,919	0,06
1	-6,7	0	62,767	65,305	64,036	0	3,442	0,884	4,812	12,104	-4,68823	1,803	0,055
2	-6,7	0	62,572	65,118	63,845	0	3,444	0,884	4,814	12,113	-4,658806	1,85	0,053
3	-6,7	0	62,506	65,082	63,794	0	3,444	0,885	4,829	12,132	-4,572791	1,873	0,052
4	-6,7	0	62,856	65,165	64,011	0	3,442	0,884	4,804	12,094	-4,744516	1,67	0,05
					64,1272								

Steel A1x150C
"B" formamide

Time, s	X, mm	T(Angle, °)	CA(L)	CA(R)	CA(M)	Tilt	L, mm	H, mm	Vol µl	A, mm2	Beta	Fit tilt	r(pix)
0	-11,7	0	70,086	72,271	71,179	0	3,242	1,096	5,397	12,256	-0,593588	5,695	0,061
0,985	-11,7	0	70,1	72,299	71,199	0	3,242	1,096	5,404	12,264	-0,59903	5,665	0,06
2	-11,7	0	70,096	72,161	71,129	0	3,244	1,096	5,404	12,266	-0,583077	5,437	0,06
2,985	-11,7	0	69,986	72,163	71,075	0	3,244	1,096	5,415	12,282	-0,576718	5,803	0,062
3,985	-11,7	0	69,93	72,167	71,048	0	3,245	1,096	5,42	12,289	-0,566594	6,04	0,063
					71,126								

Steel A1x150C
"A" ethylene glycol

Time, s	X, mm	T(Angle, °)	CA(L)	CA(R)	CA(M)	Tilt	L, mm	H, mm	Vol µl	A, mm2	Beta	Fit tilt	r(pix)
0	-16,7	0	74,699	75,569	75,134	0	3,098	1,106	5,024	11,563	-0,710176	1,747	0,044
1	-16,7	0	74,46	75,53	74,995	0	3,106	1,106	5,038	11,592	-0,714405	2,076	0,046
2	-16,7	0	74,5	75,542	75,021	0	3,107	1,105	5,035	11,589	-0,733367	2,068	0,045
3	-16,7	0	74,432	75,463	74,947	0	3,109	1,105	5,049	11,61	-0,726961	2,145	0,049
4	-16,7	0	74,544	75,463	75,003	0	3,108	1,105	5,038	11,594	-0,742324	1,861	0,046
					75,02								

Al - Foil "D" water

Time, s	X, mm	T(Angle, °)	CA(L)	CA(R)	CA(M)	Tilt	L, mm	H, mm	Vol µl	A, mm2	Beta	Fit tilt	r(pix)
0	10,2	0	103,511	103,401	103,456	0	2,322	1,407	4,515	10,583	-0,144554	-0,438	0,062
1	10,2	0	104,761	104,576	104,668	0	2,311	1,431	4,615	10,762	-0,140739	-0,565	0,061
2	10	0	106,428	106,677	106,552	0	2,293	1,466	4,764	11,03	-0,139174	1,094	0,062
3	10	0	102,784	102,915	102,849	0	2,327	1,396	4,465	10,497	-0,146975	0,658	0,061
4	10	0	104,988	105,055	105,021	0	2,307	1,429	4,608	10,753	-0,158946	0,267	0,061

Al - Foil "C" di-iodomehtane

Time, s	X, mm	T(Angle, °)	CA(L)	CA(R)	CA(M)	Tilt	L, mm	H, mm	Vol µl	A, mm2	Beta	Fit tilt	r(pix)
0	0	0	63,047	62,555	62,801	0	3,133	0,826	3,662	10,051	-2,999801	-0,405	0,049
1	0	0	62,369	61,965	62,167	0	3,126	0,818	3,59	9,951	-2,927236	-0,385	0,054
2	0	0	62,497	62,196	62,346	0	3,128	0,819	3,615	9,987	-2,952584	-0,279	0,052
3	0	0	61,34	60,984	61,162	0	3,104	0,796	3,453	9,751	-2,983287	-0,407	0,052
4	0	0	62,928	62,502	62,715	0	3,131	0,823	3,641	10,022	-3,015184	-0,384	0,053

Al - Foil "B" formamide

Time, s	X, mm	T(Angle, °)	CA(L)	CA(R)	CA(M)	Tilt	L, mm	H, mm	Vol µl	A, mm2	Beta	Fit tilt	r(pix)
0	0	0	89,187	89,311	89,249	-0,5	2,377	1,122	3,287	8,489	-0,238745	0,148	0,06
1	0	0	89,061	89,434	89,248	-0,699	2,376	1,12	3,278	8,473	-0,246266	0,607	0,057
2	0	0	89,053	89,397	89,225	-0,699	2,376	1,118	3,274	8,466	-0,248348	0,556	0,057
3	0	0	89,771	89,856	89,813	-0,599	2,377	1,131	3,327	8,556	-0,244336	-0,167	0,052
4	0	0	89,032	89,211	89,121	-0,599	2,377	1,118	3,273	8,465	-0,242155	0,157	0,055

Al - Foil "A" ethylene glycol

Time, s	X, mm	T(Angle, °)	CA(L)	CA(R)	CA(M)	Tilt	L, mm	H, mm	Vol µl	A, mm2	Beta	Fit tilt	r(pix)
0	0	0	85,209	85,024	85,117	-0,4	2,697	1,161	4,253	10,12	-0,40894	-0,854	0,054
0,984	0	0	82,115	81,918	82,016	-0,599	2,698	1,11	3,979	9,717	-0,38998	-1,143	0,056
1,984	0	0	83,217	82,995	83,106	0	2,71	1,13	4,107	9,914	-0,412267	-0,685	0,058
2,984	0	0	82,381	82,242	82,311	0	2,711	1,115	4,031	9,804	-0,418893	-0,329	0,057
3,984	0	0	82,101	82,085	82,093	0	2,714	1,114	4,037	9,815	-0,41882	0,044	0,056

Figure 2. Steel and Al-foil fragment of measured surfaces data.

To control the printed media surface energy value in flexography production printing is a common printers competence, but not for offset printers [1]. To introduce this competence to printers, we had to train offset printers to understand what will happen when on surface of the steel or Al will be covered with white base coat. What mean the white base coat surface curing and how the solvent evaporation quality is influencing the later printing quality? We had to train and instruct offset printers to the basics of flexography printing technology. Coating machine printing unit is a common flexography-printing unit [1, 6] see Fig. 3.

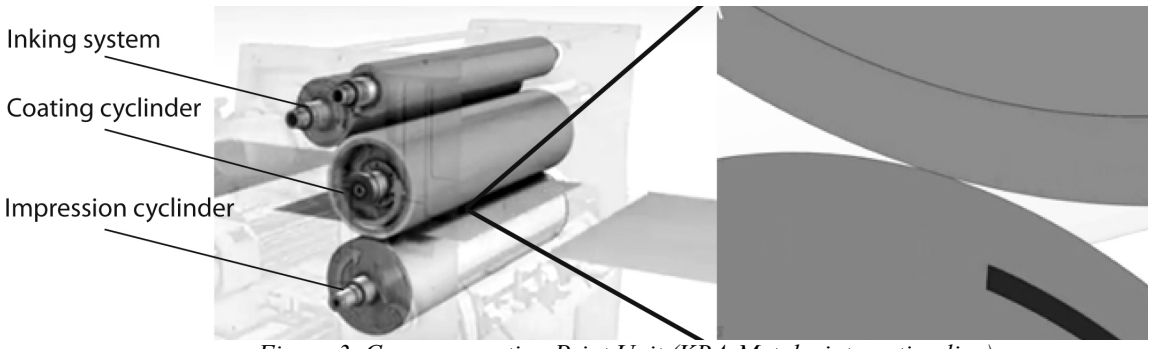


Figure 3. Common coating Print Unit (KBA-Metalprint coating line).

From point of printability the press operator shall keep the surface energy of white coating between 38 – 40 dyne (1 dyn cm^{-1} = 1 mN m^{-1}) after the coating has laid down and dray on the surface of the non-absorbent print media [1]. This is common competence for flexography printer, but not for conventional offset packaging printer. From printing ink point of view this surface energy value shall be kept for the following printing ink application as well and cannot be changed during the draying or curing process. Draying of the thermoplastic body is result of evaporation solvents from coating volume by increasing temperature. Warning – if the solvents residues remain in side of white coating it will attack dramatically the required surface characteristic values and example future wet-on-wet offset printing is destroyed [1, 3].

In this whitepaper, we introduce, as sample only one thermoplastic base coat for the non-absorbent substrates with similar surface behaviour. Our goal was to determine the white base coat CIELAB values that correspond to ISO12647-2 and Fogra 39L characterization table white point value for the paper type 1 and 2 [2, 4]. Why this is important?

In most cases the ISO12647-2 standard and Fogra characterization tables gives very well defined process guideline [2, 5]. In commercial offset printing this method is well used in practice from Contract Proof process up to Process Standard Offset (PSO) certification. But, immediately then in the system one variable is changed (example: paper type 1 changed to non-absorbent substrate or the paper CIEb* value is lower then -4) most printers face problems and often cannot find the help as well from outside services. Brand Owners using always different printing technologies to promote their products and expecting that all their Trade Marks will look same and shall have a same colour gamut. We achieve it with the process study, analyse and communication between base coat vendors. We established stable and sustainable white base coat technical guideline for the metal printing media and was able to determine the values future printing ink application and colour management.

Our studies started a few years ago. In beginning most of base coat vendors said, this is our common product and you shall live with that. Due that process was not standardized enough our white base coat CIEL* value fluctuate over ΔE ~8 points. The main reason was that the process was not analysed enough basically and even delivered white coating batches had different viscosities already from factory, apart from in house dilution process at coating press was not monitored. Other process variable as temperature was not taken into account and shifted between shifts and seasons. Then we study the base coat pigmentation we find out that pigmentation is sufficient to achieve the aim CIEL* value of 93 [2, 5], using aim value measurement from Black Backing table CIEL*93,a*0,b*-3 [2, 5]. Non-absorbent substrates, as steel and Al can be measured using the PSO Black Backing aim value tables. In production process we had to determine the dray film weight of coating in grams per sqm. Based on those values the production CIEL*93 was achieved and kept stable during everyday production, see Fig. 4.

Above the CIEL* aim value was determined the CIEb* aim value that depends from the whitening pigmentation of the white base coating (similar adds as the OBA in common paper manufacturing process).

With adjustment of those two aim values production we set up for the future ISO12647-2, -6 and -7 standard processes.

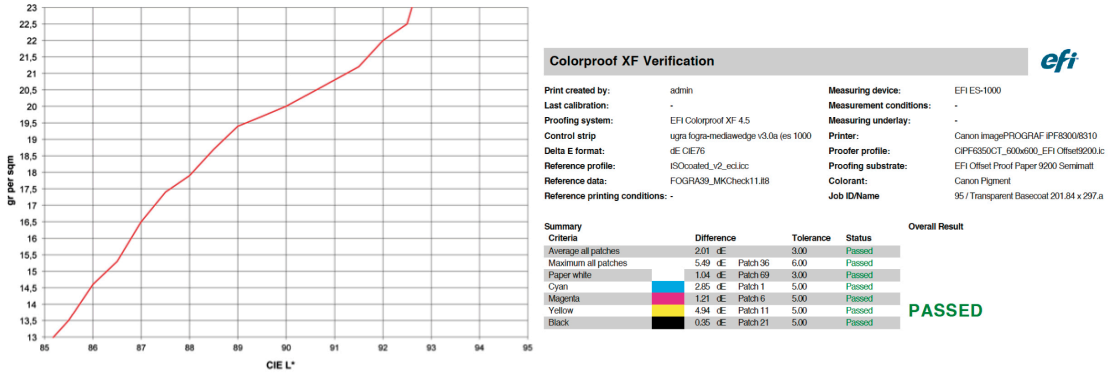
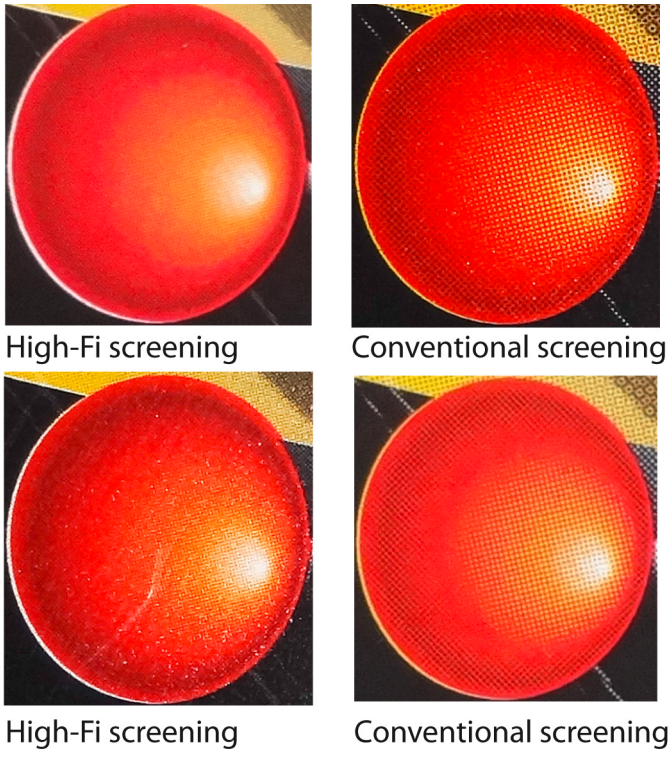


Figure 4. White base coat dry weight vs. CIE L.*

Flexo and Offset technology

Critics mostly say, it is very difficult to standardize the flexography process due that there are to many variables in process to be controlled. Generally they are right, but then we will standardize the processes we shall first study the process limitations, define what variables could be fixed and eliminated. It applies to offset technology as well! Only small portion of offset and flexography production can be run under standard conditions, for other productions we shall use ISO standards as process guideline and adjust the production accordingly. Using the non-absorbent substrates and white base coat, above we showed, how fix and eliminate critical variable from process.

Same applies then the flexography technology is analysed. In common CMYK process printing engineers shall determine the solid area dray ink film weight of the primary colours on the white base coat surface. From the appropriate white base coat and primary colours setting, can be determine the quick grey balance reference value. In modern flexography technology monitoring ink viscosity in side chamber doctor ink system, it is a routine. Solid area dray ink film thickness depends from the screen (anilox) roller cell count (line cm^{-1}) and theoretical ink volume (cc sqm). Knowing the dray ink film weight and corresponding CIELAB aim value we can fix required screen roller technical data. Using thin plate technology, double adhesive tape and plate ShA hardness can be easily defined and fixed [1]. Printing plate screen count and ruling in modern flexography technology follow the offset trends. With high-fi screening technology in flexography and offset we are able to adjust mathematically screen dots in highlights to make extremely nice vignettes on images, see Fig. 5.



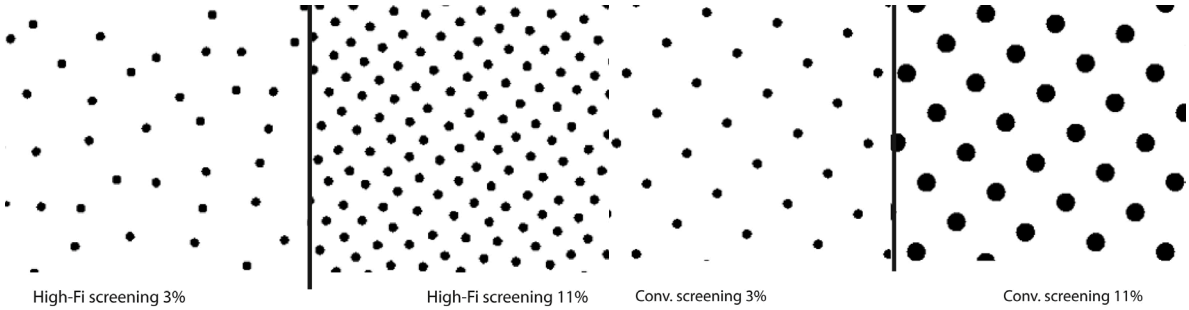


Figure 5. High-fi screening vs. conventional screening.

Conclusion

Using non-absorbent substrates print media and monitoring the white base coat CIELAB aim value in packaging production we can secure sustainability of the printing industry for several future years. With united efforts at high schools, universities, on field engineers – we can prepare best young engineer to enter on changing Graphic Art industry market. Co-operation between different engineers can speed up new process standard guidelines for the printing production and supporting printing industry to earn more profit by using standardized production processes, ISO12647-x standards and tolerances. Experiences and competence we got from the industry studies we can give a hand to TC130 working group to develop new ISO standards guidelines faster, due the printing technology is in rapid change. Basic knowledge about white base coat values, CMYK primary colours and analyses of the printing process limitation during production standardization can be added in to the engineers curriculums in early stages of studies. Introducing the standardisation processes in curriculum, it is not simple task and requires lot of discussion, theory explanations and hands-on laboratory tests. Young engineers entering into the printing market with good knowledge of the printing production processes standardisation can manage in house production process standardisation. Production standardization projects are not cheap, but it pays off costs sooner then it can be expected.

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Author biography

Enn Kerner is MSc technology engineer, graduated 1987 from Moscow State University of Printing Arts, update the flexography technology knowledge at DFTA and HDM Stuttgart by Prof. Meyer. He has updated his competences with the diploma study at Tallinn University in field of vocational and adult teaching.

As the technology engineer, with experience 25 years of practical works, was rebuilding and starting up different new printing plants (flexography and offset technologies) with a new production designs and technologies. Working closely with Graphic Technology Research Association Fogra as PSO Partner, implementing colour quality and production process standards in printing industry.

As the visiting lecture at Aalto University and vocational and adult teacher, has introduce the ISO12647-x standards requirements in to the printer operators and engineers studies. He is active in technology studies and development projects as project manager.

Case Study on the Transformative Printing Business

John R. Craft[1], Thomas S. Spotts[2]
[1]*Appalachian State University, United States*
[2]*Ball State University, United States*
craftjr@appstate.edu
tspotts@bsu.edu

Keywords: transformed print company, case study research, printing industry

Abstract
Digital media technologies are causing print media companies to transform or adapt their businesses to the demands of clients seeking a variety of new services such as content creation for social media, smartphones, and tablet computers. It is no longer just the business of print. New services for communications media are emerging among traditional print companies transformed by innovations such as cross media. As noted by Jackie Bland, the printing industry is evolving into transformative workflow, offering customers new services representative of interactive social and mobile media. Those who teach in higher education need to become aware of the changing dynamics of the graphic communications industry. The transformation of printing services is becoming a direction (and possibly, a new segment of the graphic communications industry) for companies to adapt to the new age of digital services as well as printing.

1. Introduction
Recently, Jackie Bland reported findings from research on the transformation of the printing industry in the United States in the trends issue of the Printing Industries of the America's trade publication, *The Magazine* [1]. Cross media is causing companies to rethink their business structure and go beyond by expanding their services. This transformation in printing appears to be one path for companies to remain successful during our current economic times.

2. The Purpose of the Study
Printing businesses are in transformation worldwide. As Bland pointed out, "the world has entered an era of interactivity where media usage converges." Many opportunities in the era of interactivity for a transformed printing are possible with the guidance of strong leadership pulling together human resources and talent to capitalize on a changing market. This study uses the case study research design to gather relevant information to determine the status of a printing company that is in the transformation of services.

3. The Interview Questions
Two case study research techniques were used in gathering data: interviewing and participant observation [2]. Based on a literature review of printing company transformations, a series of questions were developed and asked of the participant in this case study, Brad Masai, President of the Wentworth Printing Company, a division of Consolidated Graphics (CGX). The interview was conducted on Wednesday, May 15, 2013. Mr. Masai attributes Joe Davis, founder and CEO of CGX, with having the leadership that is driving the success of the print business transformation that is occurring with CGX. Mr. Davis started the company in 1985 with a clear vision of addressing the diverse behavior of the consumer. He is successful in attracting highly motivated university college graduates from many disciplines. The purpose of this study is to provide a resource for students enrolled in graphic communications degree programs.

1. How many people are employed at your company?
   Wentworth is one of 70 companies in the Consolidated Graphics group. (CGX has a 6000 plus employees.) There are sixty-two full time employees at Wentworth. Over twenty additional employees are hired from temporary employment agencies, bringing the total numbers of employees up to 80—or a yearly average of 80 employees. Some of the "temp" employees gain enough experience to advance in to full time employment.

2. How many are on the managerial track?
   "Fourteen of the employees are on the managerial track at Wentworth; they are presently in the Leadership Development Program (LDP) and were recruited from universities. The LDPs are also referred to as '*Associates*' and upon completing the program will transition to leadership level positions with CGX. Success as an LDP is based on the individual—"every individual has their own scale as to what they want to become"—however, it must fit within the mission of corporation. An example is an individual may have as a personal goal to move into top management by running a company, working in sales, or operations. Some of the Associates may choose to specialize in technology or accounting paths. The success of the program is with those that are achieving their goal. Twenty-five of the seventy companies are run by associates, starting as young as 26 years of age."

3. How is it possible to motivate people towards this career path?

   "It's hard, because compensation is not typically the driver, for the reason that there are other competing industries. As you know, the printing industry is not a heavily profitable industry. The successful companies are going to average 3 to 10 percent in profits…that's realistically good, depending on web or sheetfed press configurations. There's not a lot of margin for excess. What we have found is that those that are successful are those that get energized by 'ink in their veins'; however, there's always the challenge and frustration of what printing creates."

4. What are the qualifications or educational background necessary for employment at your company?

   It depends on the job descriptions or assignments. Students from recruited from universities must be able to rise to the rigor of the LDP. CGX requires a university graduate with an overall 3.0 grade point average or greater.

   a. Does CGX make exceptions if a candidate is close?

      "It depends. Although a degree in Graphic Communications or related area is preferred, other disciplines are considered. Students are also recruited from Psychology and Business disciplines. CGX allowed an applicant into their LDP program with a 3.0 Grade Point Average in the major and a 2.4 overall. That individual did not succeed in the program. The company philosophy is not to rely on only one source of an educational discipline, such as graphic communications; they believe in drawing from disciplines that cultivate individuals that are effective thinkers and doers in a production environment. There are so many different facets of our business; that we limit ourselves in productivity—we have a psychology major, a elementary education major, a business major… a variety of different personalities, which is what makes us who we are." Having high performing students from diverse disciplines has contributed to the success at CGX. These students are talented having the ability to adjust the direction of the business to match the behavior of the customer requires diverse personalities having the ability to work in an evolving industry.

5. What do you think is most important for inclusion in university graphic communications curriculum in preparing students for a career in a transformed printing business? In your words, please define transformation as it pertains to commercial printers or the business of print. (Consider changes within the last five years and the impact on production.)

   "It is an evolution of the printing business—a continuation of a process that started with Gutenberg, to offset printing, to all the variables in between. Our company is experiencing multiple evolutions that involve careful strategies to address change. A plan is necessary to anticipate change that occurs in the industry. During 1999 with the introductions of new digital technologies to capture and print jobs that were typically produced on offset presses the direction of the print industry would gradually move toward digital printing presses." Benny Landa, introduced the Indigo Digital Press in 1994 at drupa. He actually designed the press in 1970. His vision for digital printing is concomitant with Joe Davis's vision. Both see digital

printing as a growing segment in the print market. In 2001, Landa sold the Indigo Digital Press to Hewlet Packard (HP) for over 800 million US Dollars. At Wentworth, there are two HP Indigo 5000s Digital Presses that are heavily used in production.

[Will CGX purchase a Landa Nano Press?] Not at this time. However, they will follow this highspeed inkjet digital press technology as it develops. Presently, CGX has five highspeed inkjet web printing presses at locations across the country. They have the Kodak Prosper Digital Press at a Maryland facility and have not been able to get the full benefits of it's capabilities- especially since it is such a new technology.

6. How fast does your company react to market change? "Extremely fast. CGX has become the largest digital footprint in the world. The key focus is with advances in digital technology." Presently, in there are five inkjet web presses across the country. They have one of the first five HP10000 digital presses in the country, with plans to add ten more. This press prints on a 79 cm (29 in) sheet. CGX as a whole, is focusing on investing in digital printing technology advancements—whether it is product, technology or equipment driven—CGX is moving in all three directions.

7. How is training addressed by your company to bring employees up to speed? The upper management of CGX guide the training that is structured in the LDP is which has become a two-year vocational program. However, the training does not stop— "It could be a lifetime vocation." The LDP Associate is sent to other companies to learn from expert employees. They also provide learning opportunities integrated into the workplace.

8. Has your company adapted to a new model workflow? "No". Is there a model workflow students should learn? Mr. Masai believes that it depends on a number of characteristics grounded in "lean manufacturing" models or the elimination of waste in a production facility.

9. In your opinion, do you think that your company is in transformation due to rapid changes in technology?

   "Yes." Presently sales of digital print are 19% of CGX sales, a 3% increase from the previous year. Eighty-one percent of the sales are based on traditional offset and flexo print processes. Growth experienced at CGX is due to investments in new technology, such as high-speed inkjets and expanded services, such as Web2Print.

   a. What do you believe are some characteristics of a transformative printing business?

      "Characteristics of a transformative print business have to do with making wise decisions. Joe Davis has a vision to increase the technology infrastructure of CGX by gradually shifting jobs to digital printing presses as a means for a modernized print workflow. This is necessary to meet the demand of customers wanting high quality low volume printing with quick turnarounds. Mr. Davis realized that the digital printing of jobs was necessary in the late 90s as digital printing devices advanced and where being acquired by commercial printing businesses."

   b. List areas in your company that is rapidly in transformation (fulfillment, more web page, cross media, etc.—are you doing them or not?) The entire CGX corporation is involved in the transformation of the printing services based on customer demands for products.

   c. What is your company doing in order to adapt to changing economic conditions? "We have to find manufacturing efficiencies to drive the cost down." The CEO uses financial reports to inform each of the companies and shareholders on the current status or health of the CGX company. From the CGX perspective, maintaining the confidence of the company shareholders by communicating the economic status and forecasts, specifically when the company is showing gains in the market. Mr. Masai monitors the progress of the company shares by checking the reports directly. He also checks the progress of competitors such as R. R. Donnelley and Sons, and Cenveo. "I personally enjoy following the stock… it allows me to see what's going on. A good example is that Donnelley had a slight increase today—.24% and CGX at

7%. The report you listened to had a positive response on Wall Street. Mr. Davis makes use of a conference call to address all 70 member companies, shareholders and brokerage firms."

d. How do they perceive themselves—do you think of yourselves as a traditional printing company?

It is Joe Davis's plan to continue CGX as one of the most efficient and profitable print and digital media companies in the world. The recruiting and grooming of strong university graduates to move into the Leadership Development Program and become the future company presidents, sales, technical, operational body of the this company as it transforms as technology is created is the overarching strategy driving CGX to be one of the strongest commercial printers in the world.

10. Sales as the driving force—We have a market that has a variety of needs; short or long runs—are your customers the same or different before the transformation of the printing business? "I believe sales reps are the ear-to-the-ground, the face of the customers."

11. Has your company incorporated new services such as Web-2-Print or cross media publishing (the concept of never seeing your customer)? "Yes. CGX is using Streamline as an online Web2Print store front, available for customer access 24 hours per day, seven days a week."

12. How many of your presses are offset lithographic? "There are four 40" offset presses—three Komori and one Heidelberg. Additionally, there are two Heidelberg QuickMaster Offset Presses."

13. What percentage of the production workflow in your company is automated? "Twenty percent of CGX is totally automated. This has to do with the Streamline and Powerswitch digital storefront services available."

14. What percentage of your business is digital print production?

"Forty percent of the print business at Wentworth is digital print production." [During my tour of the facility, the equipment was in use. There appeared to be great respect for the high skilled production employee. There was an employee 77 years of age, operating bindery equipment.]

15. Please describe the current state of the business of print.

"For CGX, it has experienced growth in sales meeting demands for temporary point of purchase displays to address expanded services for large and grand format print markets driven by customer demands."

16. How do you recruit personnel for jobs for this company?
"For those entering into the LDP program, CGX sends representatives from companies near schools. They have impressive signage and promotional materials that explain the LDP program. Jobs in the production area require high skills of press operators. Recruitment may occur directly from trade schools or temporary agencies. The expectation and key attribute new employees requires a strong understanding of printing technology or other technical drivers such as Web2Print or cross media."

17. Can you think of any questions not addressed that are concerns for a printing business that has transformed into a complete digital workflow? None.

4. Summary

Transformed printing companies, such as Wentworth printing, have the leadership that is careful in shaping the direction of the company to the needs of their customers. Access to the services that go beyond print is the strongest characteristic a transformed business can offer. A company, such as Wentworth Printing, is part of a network of Consolidated Graphics Companies that have specialties that can be supportive to their location. If there is not a service that can provide for a customer onsite, their sales team knows the strengths of the other 69 companies in the chain.

The new services of transformed printing companies are dependent on the organizational structure and financial stability of the company to withstand the costs of making the change to more automated services. As cautioned by John Foley [3], "Not every business will or should convert. There will be a need in the foreseeable future for companies who can deliver commodity printing such as business stationery and static brochures. But those businesses are likely to be fighting it out with companies like Vistaprint or Mimeo, winning only by taking margins almost to the breaking point." For students and educators of graphic communications, the understanding of print business in transformation must be addressed in a program of study to adequately supply the needs of a changing industry.

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John Craft is a Professor teaching in the Graphic Arts and Imaging Technology Program at Appalachian State University, Boone, North Carolina.

Thomas H. Spotts is an Associate Professor and Coordinator of Graphic Arts Management/Printing Technology Programs in the Department of Industry and Technology at Ball State University.

Mass Customization of Print Products

Anne König
Beuth University of Applied Sciences Berlin, Germany
anne.koenig@beuth-hochschule.de

Keywords: Business Model, Web-to-Print, W2P, Online Printshops, Mass Customization, E-Business, E-Commerce

Abstract

Over the last 12 years, the business model for commercial printers has changed fundamentally. Before wide use of the Internet, most commercial print products were ordered and produced individually in a piece production process. The customer defined the final size, the number of pages, the amount of copies, the paper grade and many other details. Since the emerging of online ordering of printed products, the offering of a web-to-print (W2P) define the product. Customers can only order what the print company offers. Due to the individual content of each order, we can call this production process "mass customization".

This new business model enables printers to leave the inquiry and order process to the customer, to reduce make ready time due to standardization, to collect several orders on one sheet of paper larger than ever (gang run printing, using sheet fed printing presses up to size 7, up to 63 inches), and as a result to reduce the cost of small orders dramatically.

The paper presents the underlying business model in detail and discusses four critical success factors: price leadership compared with traditional organized print companies, publicity, service and continuous improvement. Examples from German Online Printers (e. g. CEWE color (Saxoprint), Flyeralarm, Laserline) cover their history, their value added chain and some highlights of the production processes. Future potential for growth of German Online Printers is mainly seen in the Europeanization of their business model.

The paper concludes that the ongoing learning curve of leading German Online Printers will enable them to keep on reducing costs and enlarging the product range. The market barrier for newcomers is strong. But the idea of mass customization of printed products gives more business opportunities than those Online Printers offer. There are much more market gaps for newcomers who have innovative ideas and are able to play the game of e-commerce, mass customization and internationalization.

The emergence of Online Printers – small business as a gap in the market

Most of us know them trough own experience: e-commerce companies offering short run printing products for nearly all marketing material you need. It's easy to order, fast delivered, the quality is better than expected with prices a traditional local printer gets pale – and he will buy there by himself. These companies specialized in marketing material for the B2C market grew fast over the last 12 years. That's remarkable due to a very competitive and decreasing market segment of commercial printing. What do they do others don't?

There is one common idea of all founders of the first online printing companies: To serve small business companies with low price but high quality professional marketing material. The first movers started their business between 1995 and 1998. At that time most of the midsized printing companies with modern machinery showed no interest in these small clients with their small orders and above all their small knowledge how to prepare the print data. These customers needed a lot of consultancy, individual cost estimation, had a small budget, and were not expected to order larger printing products in the future. For their small business they need only business cards, perhaps some marketing folders, and that's all.

Robert Keane, President and CEO of Vistaprint, the first mover and now estimated the number 1 of all web-to-print companies worldwide with 3.500 employees [1], $ 1.150 billion revenue in 2012 and 13 % to 14 % growth per year since 2002 [2], summarized his idea in his business plan in 1994 during his M.B.A. studies in Fontainebleau, France: "Imagine you are a small business (…). You want to develop a professional and aesthetically pleasing image. The market today does not provide a solution to meet your needs. Everyone knows that the terms high quality, color and professional design simply don't belong in the same sentence with inexpensive, low volume, easy or quick. This incompatibility represents a gap in the market. Simply put, there is a clear market need. [3]". Robert developed a direct marketing catalogue and started his business in Paris, France, 1995 [4].

Other country, related story. Thorsten Fischer is the founder of Flyeralarm, estimated the number 3 of all web-to-print companies worldwide with 1.500 employees [5], Germany. Before founding Flyeralarm he worked as a sole entrepreneur in Würzburg, Germany, and published a city magazine in a remarkable run length of 10.000 copies. The magazine was financed by adverts from local businessmen. His clients, the other small entrepreneurs, asked him to design and print not only their adverts but also their marketing material – more professional designed business cards and folders for example [6]. Due to his contacts to local printers, he tried to help as a broker. He wondered why these short run orders had a longer delivery time than his high volume city magazine. He saw the market gap and had the solution: Gang run printing. He collected the orders, stopped his publishing business and started Flyeralarm in 2002.

Figure 1 illustrates the market gap: Get new business from small customers with the need of professional marketing material.

Fig. 1. Microbusiness Needs as a Market Gap [7]

Small business as a market gap is one part of the success story of web-to-print companies with shops open for B2C clients. In the pre-internet time small business with the necessity of in-depth consulting was done by local small companies. The first movers like Vistaprint and Flyeralarm also started as small entrepreneurs without using the Internet. But as often in economy: you need people as innovators *and* technical innovations. In the case of Online Printers the technical innovation was e-commerce.

E-Commerce and the "Long Tail"

DRUPA 2000 will stay in my memory as "dot.com"-DRUPA. In one hall around 20 start-up companies from different countries offered software for E-Procurement. Their business idea was to get paid through commission for bringing together customers and printers through their Internet portal. Customers had to fill up online forms for their inquiry, and different printers as certified platform partners offered a price – all was done on the portal. The business model failed in the end, but the first tools for form based online configuration of print products were in the market. Around the same time, Vistaprint started its e-commerce shop [4]. Others, like Flyeralarm, followed 2002 [6].

The history of e-commerce is older than the history of web-to-print. Amazon sold its first book in 1995 [8]. E-commerce for articles like books is much less complex than online configuration of print products, which has to be ordered first and printed after ordering. But Amazon and the first movers of online ordered print products had one in common: they all started with small business. Jeff Bezos, founder of Amazon.com, started his success story with rarely sold books. Due to the costly storage of traditional bookshops, they were not interested in these book titles [9], and that was one of Amazons market gaps. Amazon and web-to-print companies have another common history: rapid growth.

Rapid growth with small business in e-commerce is often explained by the Long Tail Phenomena [10]. Vilfredo Pareto, an Italian economist of the 19th century, described it first. An example is visualized in Figure 2. If you took the Top 100 List of best selling books worldwide in history from the German Wikipedia [11], you will get a perfect Pareto Diagram or, as it is termed in the English-speaking world, a Long Tail: the total number of copies of the 20 bestselling books (20 %) is 6.8 billion numbers of copies. The following 80 book titles (80 %) are sold 1.7 billion times. That's only 20 % of the total number of copies of all 100 listed best sellers. To put in a nutshell: 20 % of the bestselling books comprise 80 % of the total number of their copies.

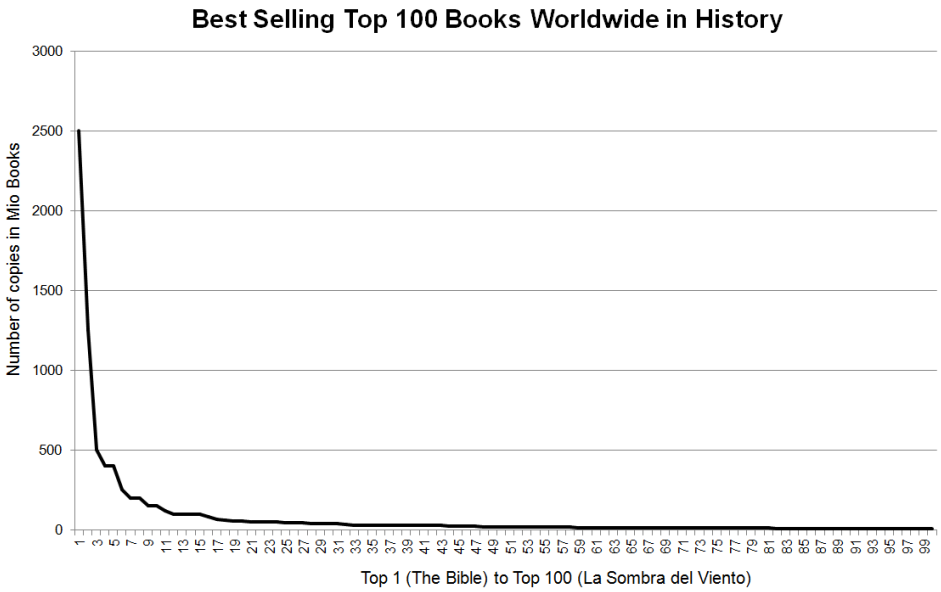


Fig. 2. Long Tail Phenomena Example

The same effect can be seen in business. An example: Most companies do 80 % of their revenues with only 20 % of their customers. To focus on the most important customers, a management categorization technique is used to figure out these 20 % of customers. Key account managers focus on these customers. And the rest, the 80 % of the customers in the long tail, are often managed more or less randomly.

Due to globalized e-commerce shops with their self-service technology, this thinking is history. The Long Tail with all his niches of customers and items became and becomes a starting point for new companies with new ideas – with a potential to grow fast in a niche. And as we can see with Amazon and today's German web-to-print companies: Starting with small business does not mean to constrain yourself to the items or customers of the long tail. The experience curve can hit you from a niche player to a market leader – if you know how to play the game, and if you are among the first in the market.

Critical success factors of Online Printers as market barriers for newcomers

In the last five years I had the opportunity to observe the development of three leading German sheet fed web-to-print, focussing on small business items: Flyeralarm with their plants in Bavaria and Saxony, CEWE Color with their youngest acquisition Saxoprint, founded in Dresden, and Laserline, a first mover in the online print business with today 150 employees in Berlin.

Visiting these companies, doing online research with print and media engineering students and studying the print specialized magazines, it can be concluded that there are four critical success factors for today's web-to-print companies:

- Price leadership compared with traditional printers
- Service
- Publicity
- Continuous improvement

There is no ranking between these four critical success factors. An Online Printer must be able to meet all of these four factors to be a growing part in his market segment. In the following sections they will be discussed in detail.

Price leadership compared with traditional printers

Four times since 2007 my students checked the prices of 30 German web-to-print companies [12]. The online query was always the same, a typical marketing folder for small business: 1.500 copies of a 6 page folder, final size 1/3 DIN A4, printed 4/4 in offset printing quality. Students chose comparable paper from the offered lists (matt coated between 135 g/m² and 150 g/m²) and the offered final sizes (between 9,8 cm and 10,5 cm x 21,0

cm). If the web-to-print shop offered not exactly 1.500 copies, students took the larger quantity (up to 2.500 copies).

Table 1 shows an extract of the survey. Rows 1 to 4 list the prices of the Top 4 Online Printers in Germany, Flyeralarm, unitedprint.com, Saxoprint and Onlineprinters, on four different query dates. Row 5 shows the difference between the lowest and the highest price in percent. In 2007, the difference was 60 %, in 2008 still 58 %. Then the price difference gets smaller to today's 12 %.

This price adjustment is the first awareness. The second finding is the continuous price reduction. Row 6 shows the average price of all dedicated web-to-print shops. It declined from year to year – during the observed five and a half year the reduction is 24 % (row 7). The price reduction cannot be explained by external effects: the external cost driver of the printing industry, the graphical paper, was more or less stable over the period (+ 0,6 % [13]).

Price adjustment and price reduction shows a huge competition in the market of Online Printers. Every company must be able to continuously improve their business to reduce the costs. Otherwise they would go bankrupt over the years.

The survey also shows: many companies could grow in the market, although they had and have different prices. Price is a very important, but not the only reason for customers to choose their print supplier.

Table 1: Price/Cost Check Online Printers and traditional printers from 2007 to 2013

			Data Collection Month/Year			
Row	Company Name	URL	11/2007	9/2008	9/2010	5/2013
1	Flyeralarm	www.flyeralarm.de	83,78 €	83,07 €	83,07 €	73,39 €
2	unitedprint.com	www.print24.de	123,64 €	118,64 €	76,88 €	65,71 €
3	Saxoprint	www.meindruckportal.de	77,07 €	75,14 €	67,62 €	72,00 €
4	Onlineprinters	www.diedruckerei.de	89,00 €	89,90 €	81,80 €	73,72 €
5		Price difference min - max	60 %	58 %	23 %	12 %
6		Average price between companies	93,37 €	91,69 €	77,34 €	71,20 €
7		Changes from 11/2007 to 5/2013				- 24 %
8		Cost Estimation with data from [14] [15]				244,10 €
9		Difference Cost Estimation / Online Printers				- 71 %

Another reflection can be done comparing the average actual price of 71,20 € from Online Printers in 5/2013 (row 6) with the cost estimation of 244,10 € in row 8. 244,10 € is the result of a cost estimation process of the described example folder, using data from the German Printing and Media Industry Organization BVDM [14]. Since more than 50 years, BVDM does intensive data maintenance about cost structures of German traditional small and medium sized print companies. The estimation was done with current computer to plate technology, a four-color press in 50 cm x 70 cm format range, running two shifts and standard post press technology. The paper costs of the 1.500 folders are estimated using average prices of the German market observer company Paperconnect [15]. The cost estimation was done without adding profit.

The conclusion is: If an average traditional printer with modern machinery had to print that folder, he had to handle costs 71 % higher than their online competitors. This enormous price difference is the reason, that meanwhile many traditional printers do reselling with W2P-companies and stopped producing print products not suitable for their cost structure.

It might be argued that the low prices of W2P-companies in this high competitive product area of folders do not cover the real costs of web-to-print. In the case of Flyeralarm there are additional data. Ulrich Stetter, member of the management of the print plants of Flyeralarm, organized as its own company named Druckhaus Mainfranken, offered a deeper inside in their cost structure on an internal speech during an excursion of Beuth University in 2012. Table 2 compares his data with a BVDM estimation, separated for the different production processes. The example of Ulrich Stetter was a folder, 2.500 copies, 6 pages, final size DIN A 4, printed 4/4 on gloss coated paper 135 g/m². Table 2 compares BVDM data with his data, separated into the different production processes. We see a reduced price difference compared with the described folder before, but it is still enormous: In this case a traditional printer has to handle costs 48 % higher than Flyeralarm.

The last row of table 2 shows the result of a query about the described A4-folder in may 2013. The price of Flyeralarm is lower than the costs showed by Ulrich Stetter a year before. It can be supposed that the experience

curve of Flyeralarm is an ongoing process, and that they were able to reduce costs during the last year to stay profitable in all products of their product range.

Table 2: Cost of Production Processes Trational Printers / Flyeralarm

	BVDM [14] / Paperconnect [15]	Flyeralarm (internal 2012)
Datacheck, CTP	36,40 €	22,00 €
Printing	171,60 €	33,00 €
Post press	59,50 €	21,50 €
Packaging	11,50 €	7,50 €
Material	121,70 €	102,00 €
Administrative Costs	included in process costs	22,00 €
Total	400,70 €	208,00 €
Difference Cost Estimation / Online Printers		- 48 %
Price query Flyeralarm 5/2013		194,83 €

To learn more about the reasons for the reduced costs in comparison with traditional printers, figure 3 shows the main differences between the cost structures by comparing the different value added chains.

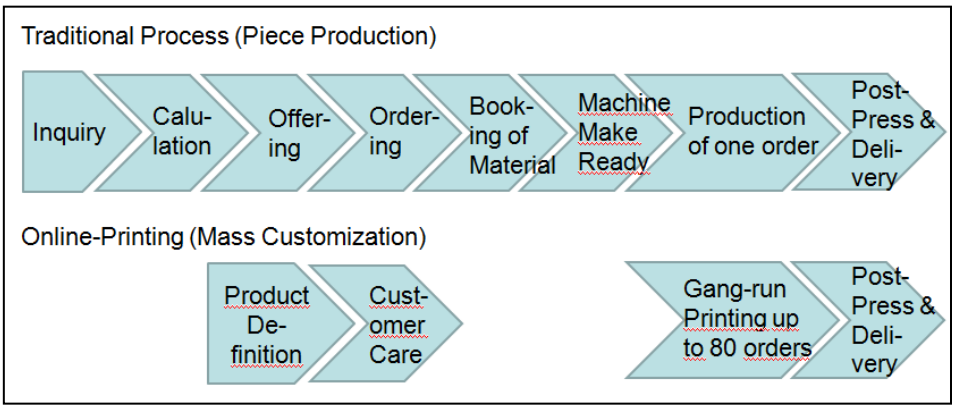


Fig. 3 .Value added chain Piece Production and Mass Customization of Printed Products

Traditional printers are organized for piece production. Every inquiry is seen as unique. It has to be estimated and offered individually. The ordering process often includes a personal customer contact like an e-mail or maybe a phone call. After ordering, material has to be booked and set up for every single order. During the production process, every process like data check, plate processing, printing, cutting, folding, has to be done only for this job. In economics, this way of production is called "job shop production": Every single job goes from one workplace to the other, and on every workplace there is not only the run time, but also make-ready-time. There is a lot of automation in pre-, print- and post press processes in the last years – but still there is make ready time needed for every single job.

Web-to-print companies use the same machinery, but their cost structure is very different. Due to customer self service, customers do the inquiry, the price estimation, the offering and the ordering. Web-to-print companies do not need skilled people for these tasks. Instead, they need skilled people to define the products they offer, to do the pricing and the adjustment for prices for the broadening product range and to develop and improve the shop system.

To build up the e-commerce system is a huge and very expensive project. The e-commerce software of all leading web-to-print companies is programmed by themselves and at the heart of their business. And it is an important market barrier for newcomers. But if you have gone through this innovation phase, the e-commerce shop is a tremendous cost cutting area: Every improvement on the website has to be done only once, and then it can be used by millions of customers. And: As more orders you have in one year, as stronger this cost cutting effect is – an important experience curve the company can use for price reductions.

The second area of tremendous cost cutting is standardization and gang run production. Both depend on each other. Without standardization of the offered paper grade, the amount of copies and the printing size, gang run printing is not possible.

Standardization as a requirement of gang run printing is what Thorsten Fischer did when starting his business with Flyeralarm. He collected the orders of his small business clients, decided by himself about the paper grade, suggested the number of copies or multiples of it, and applied let's say 16 business cards as one print run order by local traditional print companies. The cost cutting effect especially in the processes data check, CTP and printing is obvious. He could offer every business card at a much-reduced price compared with piece production. The idea of gang run printing itself is not an innovation – it is an obvious idea for everyone working in print business. But in the pre-internet time it was very work intensive to find for example 16 customers willing to buy business cards in a standardized quality at the same time. As a first mover Laserline in Berlin had this problem too. When starting their business for cheap print marketing products trying to use the gang run printing cost cutting effect in 1998, they distributed only by direct marketing a small printed catalogue called "dummy" with standardized print products on defined print days a week [16].

Gang run printing is the most advantage W2P printers have through standardization. The cost cutting gang run printing effect is the reason they buy the biggest sheet fed printing machine in the market: KBA Rapida 162a, Heidelberg Speedmaster XL 162 or Roland 900 XXL. By now they are able to collect more than 80 orders on one sheet of paper. The gang run cost cutting effect is also the reason for the difference between – 71 % in the smaller folder with shorter print run length in table 1 and – 48 % in the larger folder with longer print run length in table 2. The smaller the print size and the shorter the print run length, the higher is the gang run printing cost cutting effect.

Besides gang run printing, there are more advantages through standardization for W2P printers. Only through standardization and as a result the reduction of the variety of printing products is it possible to build up an easy-to-use e-commerce website. Only through standardization it is possible to reduce the make-ready time of folding machines producing only one sort of folder. Only through standardization of paper grade is it possible to buy paper not from the paper suppliers but directly from the paper mill.

The price leadership, compared with traditional printers, is reached through the triangle of e-commerce, standardization and gang run printing. That was the market entry. Additionally, W2P printers must reduce their internal costs continuously to stay in the market. But W2P companies customers do not always take the cheapest offer. Due to good customer's experience, repurchasing and recommendations are possible.

Publicity

The German online portal www.druckdeal.de lists around 1.200 online printers or print sellers for the product range of flyers and folders. [17]. Without a clear publicity strategy, there is no chance to grow sustainably in this multitudinous market. Publicity is the second critical success factor for today's web-to-print companies.

W2P Printers do online marketing. Robert Keane of Vistaprint described their efforts in an Interview: "... firstly we truly have become a world class practitioner of internet-based direct marketing. We have built a very strong direct marketing talent pool, which are analytical and technology-driven. Secondly, word of mouth is an important driver in our business. To put our advertising expenditure into perspective, we currently have about 300 million USD in annualized revenues, of which we spend about 33% on marketing, or about 80 million USD. Given our revenue growth, this is increasing at a rate of between 60 and 70% a year" [4].

In addition to intensive online marketing activities, Online Printers have quite different strategies to ensure long-lasting market awareness. Vistaprint strengthens its focus to B2C clients, concerning their product range, web to print design tools and marketing campaigns in B2C platforms like gmx. Flyeralarm does company branding e. g. by sports sponsoring and board advertising in soccer stadiums. Additionally they started to build up brick stores in major German cities for consultancy and pick up service. Laserline focuses on professional repurchasers of advertising agencies, print companies and graphic design studios. They conduct professional and knowledge intensive newsletter marketing, offer elaborate print job samples in their "Black Box" (with Laser-Line branding on the samples) and "White Box" (without branding on the samples for resellers use), including other helpful tools for professional graphic production. Plus, their seminars are well-known in the graphical scene of Berlin and are conducted in their impressive headquarter.

Service

The cost advantage of W2P printers through e-commerce comes along with volatile customers. As it is say: the competitor is just one click away. To build up customer loyalty, a W2P company must not only offer competitive prices, but also good service.

Service starts with the usability and service orientation of the e-commerce website. All leading German W2P printers have customer portals for order tracking, reclamation processes and easier repurchasing through archives. For professional print buyers this service sometimes is more important than a slightly cheaper price of the competitor. Online Printers focussing on B2C customers offers easy to use design services. And all leading German Online Printers conduct company owned a call centre with skilled staff.

Continuous improvement

Starting between 1998 and 2002, the leading W2P printers in Germany went to an experience curve difficult to meet by newcomers. All processes in the value added chain are under continuous improvement. The most expensive production process, the printing process, is under particular surveillance:

- To reduce the make-ready time of the print process, first W2P printers test special imposition software for gang run printing. The target is to impose the different orders in such a way that the amount of ink of every ink zone is related to the ink zone of the previous gang run. If there are 50 or more plate changes a day, five sheets of reduced waste is a critical success factor.
- Buying state-of-the-art machinery can reduce make-ready time up to 30 %. An example: Unitedcom.org with its plant in Radebeul, Germany, was the worldwide first buyer of Heidelberg Speedmaster XL 162-8P in 2011 [18]. The same machinery now is used by print factories of Flyeralarm and Saxoprint. Klaus Sauer, CEO of Saxoprint, said in an interview 2012, after buying the second XL 162 machine for gang run printing orders: “The leap in productivity possible with this machine is simply revolutionary for offset printing. Makeready times are just one third of what was previously typical.” [19]. Also most of Online Printing companies use inline density control. “When printing flyers this can cut waste by as much as ten per cent”, said Michael Deml from Flyeralarm [20].

Some other improvements over the year form post press and logistics:

- Due to modern print machinery with double gripper delivery the jogging process can be eliminated – although some Online Printers reduce the intermediate cut to 2 mm.
- Flyeralarm saw increasing demand for low volume printed envelopes. Traditional printers buy unprinted envelopes and for that reason had to handle slow printing processes. Together with Winkler + Dünnebier, a specialist for envelope manufacturing solutions, Flyeralarm developed a sheet fed envelope production machine and thus changed the process: printing the design in gang run printing with all the gang run and automation cost advantages, and doing the envelope production as a post press process.

Mass customization of print products – an ongoing growing market

Looking back at the described four critical success factors of German Online Printers and their experience curve over the last years, there are now strong market barriers for newcomers. The investment in e-commerce-software, publicity and machinery is very high, and for latecomers it is much more difficult to enter into this dynamic and competitive market. In the last year there was only one new bigger online print company with own production lines in the German market, CEWE Color with its new brand CEWE Print [21]. CEWE Color, a stock corporation and Europeans market leader for photo books with 3.300 employees [22], adjusted its business model from the B2C market of photobooks to commercial digital and offset printed print products for professional B2B customers last year by entering the sheet fed online printing market. But CEWE Color was not really a newcomer in online printing. They integrated the former top 3 of German W2P printers, Saxoprint, into their company.

German statistics and data from specialised literature allow estimation about the market potential of B2B online printing. Figure 4 shows the official published market volume of commercial printing in Germany (grey columns). This market segment decreases from 6.1 billion € in 2007 to 5.2 billion € nowadays. To get an idea about the potential of mass customized online print product, the turnovers of the five German W2P printers were summarized. Additionally, the turnover of Vistaprint and the next 15 web-to-print companies in the German

market were estimated. Using this method, online printed products started with 200 millions € in 2007 and has by now a turnover of 700 millions €. The conclusion is: Online printing of commercial products is a growing market in a declining segment. Online Printers grow through cannibalization of market shares of traditional printers.

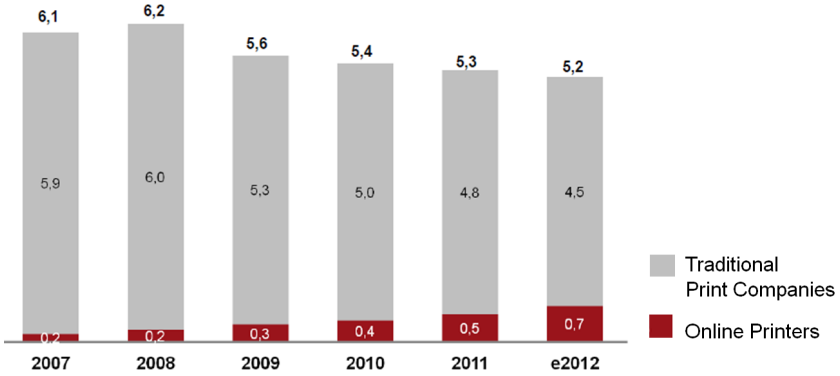


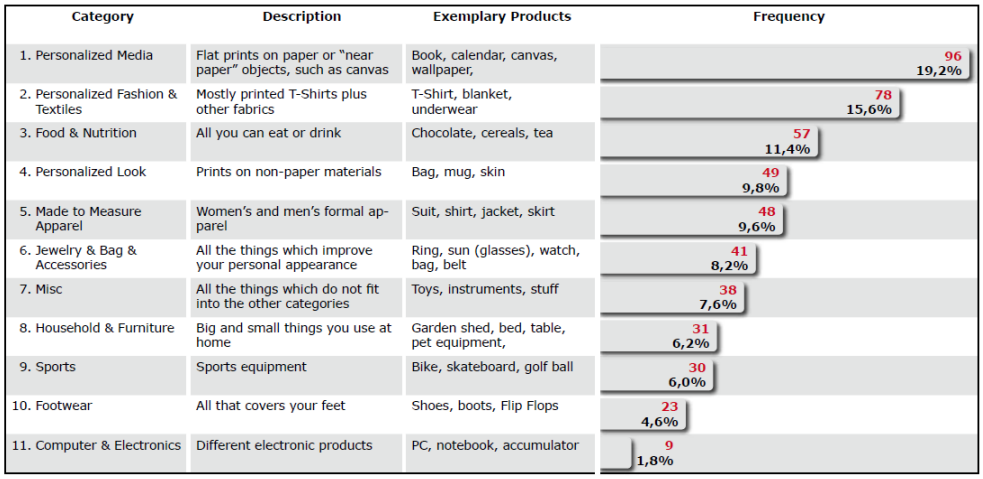
Fig. 4. Market Development of Commercial Online Print [22]

The second potential for growth is Europeanization and Globalization. All German Online Printers built up regionally adapted e-commerce sites. And Vistaprint is the benchmark. Along with one of Robert Keane strategic key point, "a commitment to being totally international in the way we think and act" [4], Vistaprint has 31 localised Websites and ships to 130 countries. Unitedprint.com follows with 24 localised websites. Web-to-print companies like CEWE Color and Flyeralarm are still in an ongoing process of internationalization with eleven, eight and six regional websites respectively.

What does this say for the majority of traditional print companies, the small and medium sized companies all over the world? For some of their business, they cannot compete against the price, the delivery time and the print quality of W2P printers. They have lost some customers with demands on short run marketing material. For others, they co-operate with W2P companies. Michael Deml from Flyeralarm described it in an interview: "You must realise that over 80 per cent of our customers are businesses, which have their print work designed by professional agencies or freelancers (...). A lot of smaller printshops also advise their customers and prepare their data, but have us print the products" [20]. The Online Printers started with B2C: small business items for small customers. Now they are in a big market segment of the B2B market.

And what does this say about future innovators? The market for mass customized printed products is much more differentiated than standardized marketing material on paper. The described long tail in the digital economy is and will be in future a starting point for new business in mass customized printed products.

An ongoing driver for successful business ideas in mass customized printed products is technology, in particular digital print technology. Figure 5 shows the result of a benchmark study of 500 mass customized products – form personalized fashion & textiles like T-Shirts to mass customized computers, the business model of DELL computers [23]. The TOP 1 is personalized media – and much more of them need print technology to be produced in an effective and cheap way: From mass customized wall paper to mass customized ceramics, from mass customized printed flip flops to mass customized golf balls. And a lot of other mass customized products need packages, for example mass customized muesli mixes.



Category	Description	Exemplary Products	Frequency
1. Personalized Media	Flat prints on paper or "near paper" objects, such as canvas	Book, calendar, canvas, wallpaper,	96 19,2%
2. Personalized Fashion & Textiles	Mostly printed T-Shirts plus other fabrics	T-Shirt, blanket, underwear	78 15,6%
3. Food & Nutrition	All you can eat or drink	Chocolate, cereals, tea	57 11,4%
4. Personalized Look	Prints on non-paper materials	Bag, mug, skin	49 9,8%
5. Made to Measure Apparel	Women's and men's formal apparel	Suit, shirt, jacket, skirt	48 9,6%
6. Jewelry & Bag & Accessories	All the things which improve your personal appearance	Ring, sun (glasses), watch, bag, belt	41 8,2%
7. Misc	All the things which do not fit into the other categories	Toys, instruments, stuff	38 7,6%
8. Household & Furniture	Big and small things you use at home	Garden shed, bed, table, pet equipment,	31 6,2%
9. Sports	Sports equipment	Bike, skateboard, golf ball	30 6,0%
10. Footwear	All that covers your feet	Shoes, boots, Flip Flops	23 4,6%
11. Computer & Electronics	Different electronic products	PC, notebook, accumulator	9 1,8%

Fig. 5: Categories and frequency of international benchmark study on mass customizetion and personalization in consumer e-commerce [23]

Like Robert Keane and Thorsten Fischer with their web-to-print companies, the starting point of new business ideas in printing industry continues to be the discovery of a market gap. From this point on, e-commerce with its chances in niches, combined with digital print technology and the ability of continuous improvement of the production process, there is an open future for the print business.

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Biography

Anne König is professor for economics in the print and media industry and director of the print and post print laboratory at Beuth University of Applied Sciences. Her main areas of research and lecturing are strategic options for print companies, print estimations, the implementation of innovative technologies and processes, and human resource management. Since 1994 she conducted 14 research projects and published over 100 articles and conference contributions. Anne König holds an apprenticeship diploma as a printer, an M.Sc. degree in print engineering and a PhD degree in education. Her doctoral thesis examines self-directed learning in SMEs.

IC2013 Social Responsibility and Design Education: Public Design Service, a Case Study on Design for the Public Good

IC2013 Alison Miyauchi
IC2012 Alison Miyauchi, Alberta College of Art & Design, Canada

When Ken Garland published his *First Things First* manifesto in 1964, he challenged graphic designers and other visual communicators to become more socially responsible by calling for "greater awareness of the world… and more useful and lasting forms of communication". (Garland, 1964) This was reiterated in the *First Things First Manifesto 2000,* which was signed by 33 prominent designers and design educators in 2000. The concept or value of socially responsible design is not new but it is one that is not always well articulated in contemporary design education, which still tends to be largely commercially focused. In educating the visual communicators of the future it is important to look at alternative ways of operating in design. Giving students practical, real-world experience is also not new to design educators as can be evidenced by the plethora of practicum opportunities available at most institutions of higher learning but tying this type of learning experience to notions of social responsibility and good citizenship is much less prevalent. Educators and education should be involved in the development of caring attitudes towards others as well as helping students grasp the various fields of knowledge as they prepare for professional design careers. Adding a community engagement piece to the practicum experience promotes a deeper sense of social responsibility among students taking them from merely becoming "well-informed" to becoming more committed to the collective work and responsibilities needed to address social and cultural issues. This type of service-learning requires students to use their subject knowledge to carry out an activity that benefits others, and the experience can empower students with practical and strategic skills that help transform communities and society at large. In turn, this teaching strategy can encourage new ways of thinking, doing, and acting with respect to civic engagement.

A Case for Service-Learning in Design

Service-learning means doing good work and serving, helping, giving assistance or benefiting others. (Kerins, 2010, p.79) Service-learning, like other teaching methods, facilitates subject learning but it also responds to students' desire to use their education to help others. It is the altruistic dimension of this teaching method that provides them with a strong source of personal learning and development. Unlike what is usually offered in the studio or classroom environment, learning locations in this model offer more variety. In these environments students are often required to learn under pressure while working with and for other people. This is real-life experience; if they fail they have to accept the consequences. Students need to deal with and manage the entire process rather than simply the faculty-student relationship. "The experiential element of service-learning can contain challenging and conflict filled situations that need to be dealt with". (Kerins, 2010, p.4) This connects classroom learning with real life beyond the academic exercise and makes it possible for students to gain a deeper understanding of course content as well as an increased sense of social responsibility. This type of experience echoes trends in the design industry where the field of social design attracts increasingly more graphic designers who crave a chance to work with underserved clients as an alternative to the more traditional design jobs in large corporations and advertising firms. Designers want to work closely with communities that need their help most and actively participate in combating complex social problems. (Shea, 2012, p.8) At the same time, service-learning in design education allows many not-for-profit organizations to access design services which otherwise are not within their budgets.

Educational reformer John Dewey (1859-1952) offers a conceptual framework for service-learning. He advocates that all genuine education comes through experience and provides support for the experiential element of service-learning. His idea that education should contribute to how we live and operate in the community supports the service element of service-learning. "I take it that the fundamental unity of the newer philosophy [of education] is found in the idea that there is an intimate and necessary relation between the processes of actual experience and education" (Dewey, 1938, p. 20). Service-learning has

occurred for all types of post-secondary education across a wide spectrum of disciplines during the past two decades and can be defined as a course-based, credit-bearing educational experience in which students (a) participate in an organized service activity that meets identified community needs, and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of discipline, and an enhanced sense of personal values and civic responsibility. (Bringle & Hatcher, 2009, p.38). Bringle and Hatcher's definition of service-learning is important in differentiating service-learning from volunteering by identifying this as an academic activity. If volunteering is defined as offering to perform a service of one's own free will, providing assistance or assuming the obligation voluntarily, then service-learning as a course or part of a course or as career development needs to be viewed differently. Service-learning combines theory with practice, the classroom with the community and the cognitive with the affective. It is a form of experiential education that enables students, in the case of the Public Design Service course at the Alberta College of Art + Design, to actively apply classroom knowledge to work with a not-for-profit organization. As students engage in action and thinking that do not necessarily follow the outlines of a textbook but follow the patterns of real problems in the world, they develop a deeper understanding of the practicality or the relatedness of ideas within a discipline and across disciplines and how those ideas have use for guiding their actions in the world outside of the classroom. (Cress, Donahue, Elrich, 2011, p.133) It can be a potentially transformative experience for the student. Learning not only occurs through the process of solving the design problem at hand and the subsequent reflection on and evaluation of that experience (which can result not only in academic and cognitive development), but also in personal and social development.

Faculty have a pivotal role in this type of learning experience by determining and assessing learning outcomes, collaborating with community partners and structuring student experiences that realize academic goals. Key in these activities is the integration of structured reflection activities that link the community service to course content and vice versa to provide a deeper understanding of both. This critical reflection adds new meaning to the experiences, enriches the course content, and develops the student's ability to make informed decisions in the future. Because much of the learning experience occurs outside of the classroom with a variety of different student/client experiences, the planning, delivery and evaluation can be a complex and sometimes difficult activity. The inevitable pressure of building links with different groups and stakeholders during the learning process adds to this complexity. From a student's perspective the service impulse can range from a largely self-improvement motive to a predominantly charity driven impulse. As a result, student intention and effort play an important role. It can be challenging for some student designers to give up a certain amount of control over their work and let the community partners' input inform their design decisions in order to fully address the design problem at hand and to ensure all parties will take ownership of it. Recognizing student efforts in service-learning also needs to be considered. Celebrating the students' accomplishments in this area is important in demonstrating that this type of learning and the services provided to the recipients are valued.

Service-learning can help students develop knowledge and skills in communication, teamwork, organization, management, time management, project management and interpersonal capabilities. Participation in a service-learning experience with a community organization also allows an opportunity for students to develop more caring selves. It is a vehicle for character and citizenship development as well as for the creation of social conscience. Another benefit is a greater sense of connection between students and the community that results from conducting shared projects. Service-learning can also help address some non-financial aspects of the design business such as social capital, civic engagement, social responsibility and sustainability. It is also clear that students need and want a learning experience that is relevant to an increasingly diverse and immediately connected world. These types of learning experiences provide educational, professional and personal stepping-stones for students, helping them to transition into their careers.

Education and training are pivotal to economic growth, international competitiveness, increased productivity, mobility of the population and to the level and standard of living. (Wang, 2008, p.90) In Alberta, the economy has dominated educational debate between institutions and the provincial government. Increasingly in the province of Alberta, the provincial government feels inclined to tell educators that post-secondary institutions need to be more results-based and "real world", in part due to the fact that competition for public funding has dramatically increased as claims on the public purse increase.

As a result there is greater pressure on post-secondary institutions to emphasize the acquisition of knowledge and skills that are largely market-driven and institutions are asked to demonstrate that they are contributing to economic development, up-skilling, and knowledge-based developments. In addition, post-secondary institutions have been tasked with greater accountability and cost-effectiveness forcing them to be focused more on economic and financial factors to secure their support base in the public mind. In addition, the dominant government voice advocates that higher education should prepare students to operate within and support the economy. This is done by enabling students to acquire knowledge and, from a government standpoint, this knowledge should be economically useful, advanced and marketable. In this model students are seen as customers who want marketable skills with the desire of developing attractive careers. This view does not address the idea of the ability of higher education to strengthen society by encouraging students to develop values that help them live more effectively with others. In fact, some criticize post-secondary institutions for not sufficiently teaching the values of social responsibility. (Freedman, 2001, p.55) A more balanced approach acknowledges the need for knowledge that meets individual career needs and that of the broader economy with principles of social responsibility.

The demand for certain social outcomes of post-secondary education is also growing. A strong contributing factor to this is community outreach or demonstrating credentials and value to the community at large. The Government of Alberta and its institutions are expected to achieve focused economic and social outcomes that it deems are of most value to Albertans. (Enterprise and Advanced Education, 2013). Echoing this sentiment is the World Bank, which advocates that higher education has a responsibility for equipping individuals with the advanced knowledge and skills required for jobs in government, business and the professions. UNESCO, through the World Conference on Higher Education, advocates for the development of social responsibility, so that graduates can become better citizens who can think critically, seek and apply solutions and accept social responsibility (UNESCO, 1995: 25-26). It can be challenging to balance academic imperatives with the idea of job preparation and government mandates. When we consider the plight of not-for-profit organizations in a time of shrinking public funding the case for service-learning becomes even more attractive to all stakeholders in the process, even though this can place additional pressure on the recipient organizations. Why would not-for-profit organizations want to take on this type of proposition? Organizations sometimes take on service learners to expand their organizational capacity. Some organizations take on service learners to build, strengthen or preserve connections to colleges and universities (Stoeker & Tryon, 2009, p.20). Others engage in this activity to fill a need in their operational capacity or to secure a service they do not possess nor could otherwise afford. A number of not-for-profit organizations utilize service learners as part of their mission to educate the public, where students are seen to be members of that public. Service-learning can have positive and quantifiable benefits for all stakeholders in the process.

The Public Design Service

Since 1984, service-learning has been a vital part of the curriculum in the School of Communication Design at the Alberta College of Art + Design though the Public Design Service. Based on the idea that design can have a positive influence on people and the world in which we live, the Public Design Service course provides high-quality communication design solutions for not-for-profit organizations and provides a practicum experience for students through doing work for worthwhile causes that can really make a discernable difference in society. The Public Design Service matches senior design students with not-for-profit organizations and community partners who have applied to participate and who have met the eligibility requirements in a service-learning educational experience. The two primary goals of the Public Design Service are: 1) to give senior design students practical, real-world experience in achieving effective solutions to creative communication and graphic design problems; and, 2) to provide charitable arts, service, community, environmental, and similar not-for-profit organizations with the benefit of quality design solutions. Secondary goals include instilling as sense of social responsibility in the students and community outreach.

In the Public Design Service course, project-based service-learning is a means of managing short-term service-learning or pro bono work. Not-for-profit organizations are highly motivated to use project-based service-learning as a way to get their work done and to tap into specific strengths and skills of students. In a recent survey, 40 of the 45 organizations interviewed highlighted contributions made by the student

designers on projects that the organizations did not have the skills for in house, and noted that the students behaved in a professional manner and solved the communication or design problem at hand with "great creativity and energy". The student designers enter the organization with a great deal of valuable skills and new perspectives providing a resource that most not-for-profits and community organizations cannot afford but desperately need. Utilizing project-based service-learning with design can create a win-win situation for all parties. It can be an invaluable resource for studio-instruction and form a connection to community important for all designers. It is clear that in today's world designers have a higher public profile, as the importance of design and the power of design to promote change have become more widely known. As Anne Bush notes, design has an important social role and design practice should be anchored in the reality of its social consequences. (Heller & Vienne, 2003, p.26)

As mentioned above, project-based service-learning in the Public Design Service extends beyond the classroom into the community. Students engage in projects that address community needs while meeting the demands of academic curriculum, taking their scholarly knowledge into the community and experiential learning back into the classroom. "This integration of pedagogy with real-world experience provides a unique learning opportunity for students, which can result in positive outcomes in their academic learning and personal development" (Stoecker & Tryon, 2009, p.73). It can result not only in academic and cognitive development but also in personal and social development. In some cases students are disappointed with their service-learning experience, most often when their expectations of the service experience are not met or because the expectations of student and recipient organization are not in alignment. Lack of effective communications is a key factor here and faculty play a very important role both in matching the student to the project or organization and also in the facilitation of client/student communication. In addition, organizations can also struggle with how to set their expectations of the young adults who sometimes have limited practical experience and who approach the organization as a learning site. It is important that the student understand the balance between their own educational objectives and the community organization's expectations. In addition, some not-for-profits do not feel comfortable with student designers working or communicating directly with their clients. Here, it is crucial to establish contact parameters at the outset of the project. The not-for-profit will also need to clearly identify the time and resources that they can contribute to the process.

In the Public Design Service course, service-learning is used to teach design problem solving, project management, and business practices including design briefs, letters of agreement and contracts. Service-learning also promotes the understanding of the social value of pro bono work through providing design services to a not-for-profit organization. At the beginning of the semester and at key points throughout the semester students learn the relevant theory delivered through lectures, course work, panel discussions and guest lecturers. The workflow chart for this course is provided below in Table 1.

IC2013 Table 1 – Public Design Workflow

Public Design Work Flow Table			
Prior to Semester **Client Registration Application** on Public Design Website or hard copy by mail **Client Selection** **Faculty Planning** including a review of the previous year's course			
Phase 1 – Weeks 1-4 - Research			
In Class	**Outside of Class**	**Assignments**	**Faculty**
Orient students to the course **Panel Discussion** – How not-for-profit organizations differ from other businesses **Lecture** – Client Relations **Lecture** – Dynamics of Design Teams **Lecture** – What is a Design Brief **Lecture** – Contracts (Guest Speaker) **Lecture** – Intellectual Property and Copyright (Guest Speaker) **Lecture** – Time Management (Guest Speaker)	Research Client Introductions	Letter of Agreement Contract Design Brief	Assess student strengths and inclinations Client meetings Assess client projects to determine whether they are solo or team projects
Phase 2 – Weeks 4-7 – Preliminary Design			
In Class	**Outside of Class**	**Assignments**	**Faculty**
Lecture – Design Thinking **Lecture** – Project Management (Guest Speaker) **Lecture** – Printing Process (Guest Speaker) Ideation and Concept Development	Research Ideation and Concept Development Client meetings	Preliminary Design Concepts for Approval by Faculty and then Clients	Framework for creative direction Guidance on client objectives and client relations Approve concepts with respect to the individual student project briefs

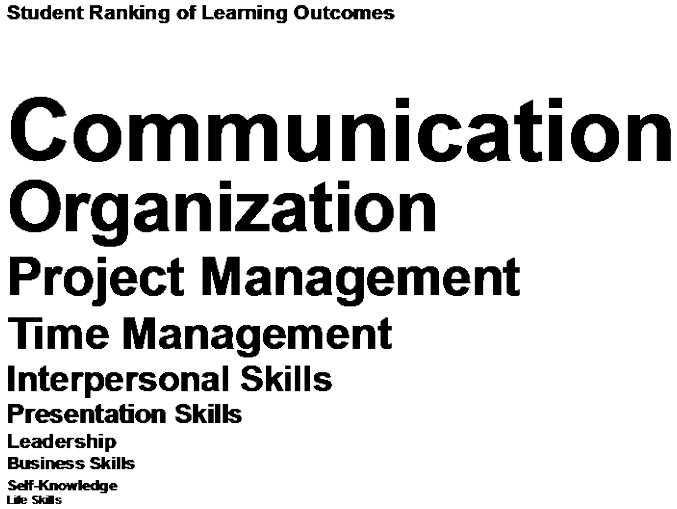
Phase 3 – Weeks 8-12 – Development and Refinement/Preliminary Production			
In Class	**Outside of Class**	**Assignments**	**Faculty**
Concept Development and Refinement Lecture – Liaising with Suppliers Lecture – Community Engagement Lecture – Nuances of Client Relations – including scope creep, rushed approvals, dealing with changes, keeping your eye on the ball etc	Presentations to Clients Securing sub-contractors (photographers, illustrators, printers, web developers etc) Community Engagement	Comprehensives, storyboards or wireframes	Troubleshooting regarding client relations, communications, sub-contractors
Phase 4 – Weeks 13-14 - Production			
In Class	**Outside of Class**	**Assignments**	**Faculty**
Production to media	Production to media	All is necessary to production in required media	Troubleshooting
Phase 5 – Week 15 - Evaluation			
In Class	**Outside of Class**	**Assignments**	**Faculty**
Student Presentations with process books and summarized client feedback	Client Service	Process book Deliverables to Client Project Summary Client Feedback Summary	Assessment of student learning outcomes Client Evaluations Student Evaluations Review of the semester

A value in giving project-based service learners a hands-on experience in not-for-profit community organizations is to provide graduates with a greater sense of social responsibility and community competency. Some organizations see these students as future staff members for the not-for-profit sector. This is not a core goal of the Public Design Service course which views this experience as fostering an understanding of the importance of supporting non-for-profit work in some capacity in the future. Students who participated in this course from 2010-2011 (approximately 60 students) were asked if they understood the benefits of pro bono work? *Pro bono publico* (usually shortened to *pro bono*) is a Latin phrase that means "for the public good." The term is generally used to describe professional work undertaken voluntarily and without payment (or substantially reduced fee) as a public service. The response to understanding the benefits of pro bono work was 100% – yes. Further when they were asked if they would undertake pro bono work in the future the response was 95% – yes. When asked whether pro bono work made them feel like they had made a positive contribution to the community, 65% of students felt that this work made them feel like they had made a positive or very positive contribution to society. The remaining 35% were neutral, most citing the fact that their work had not yet been produced and therefore were unable to judge whether the work had made a positive contribution or not. Where a disconnect was identified was when students were asked if they knew how to find pro bono work in the future. The response to this question was 75% – no. This result was reinforced by responses to a follow up question asking if students were aware of the educational and business resources available from the Society of Graphic Designers of Canada's resources pertaining to pro bono work where 75% again replied no. Clearly, further fine-tuning needs to be made to help students engage in pro bono work post graduation.[1]

Additionally, the students were asked if their service learning contributed to their understanding of the business of graphic design, advertising and/or marketing. Of the respondents, 75% indicated yes to this question. Of the 25% who responded no, 15% reported difficulties with client expectations and 10% reported that they believed they already possessed a good understanding of the business of design. When students were questioned about their views on whether the service-learning project had provided a "real life design experience" 75% responded yes, 25% responded no. Further research is required in the perceptions of this experience with the negative response group. The respondents were split in terms of whether or not they would use the work they produced through this experience in their portfolios. They were also asked to rank the following in terms of their perceived importance in the learning experience: Business Skills; Communication; Interpersonal Skills; Leadership; Life Skills; Negotiation; Organization; Project Management; Self Knowledge; Presentation Skills; and Time Management. In terms of student perception of the learning experience Communication, Organization and Project Management were given the highest rankings and Self-Knowledge and Life Skill receiving the lowest. See Table 2 – Student Ranking of Learning Outcomes.

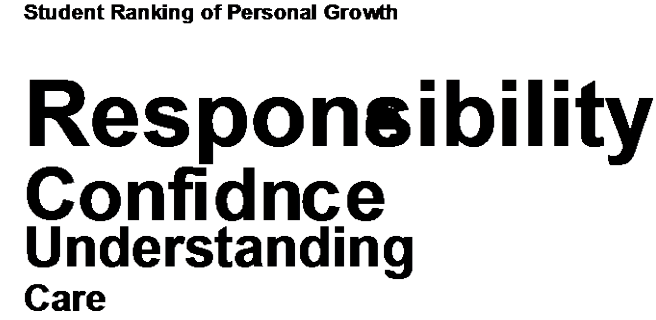
[1] Results derived from a survey of Public Design Service students 2010-2012.

IC2013 Table 2 – Student Ranking of Learning Outcomes[2]



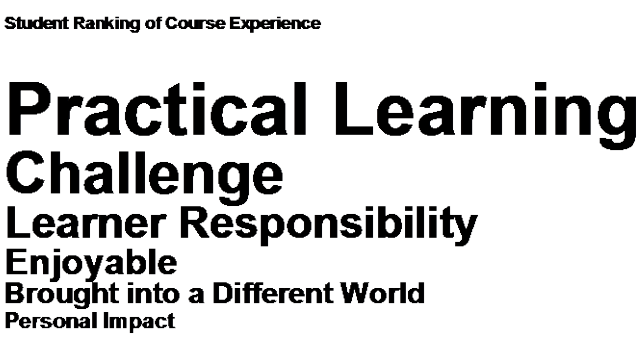
Other metrics students were questioned on were personal growth and personal course experience. Students were asked to rank the following in terms of their personal growth as a result of the service-learning experience: Care; Confidence; Responsibility; and Understanding. In the personal growth spectrum, students ranked an improvement in Responsibility the highest followed by, in order of importance, Confidence, Understanding and Care. See Table 3 – Student Ranking of Personal Growth. They were also asked to rank the following in terms of the personal experience of the course: Brought into a Different World; Challenge; Enjoyable; Learner Responsibility; Personal Impact; and Practical Learning. Students ranked Practical Learning the highest here and Personal Impact the lowest. See Table 4 – Student Ranking of Course Experience. It is clear that their service-learning experience goes far beyond discipline specific knowledge and skills to encompass the realm of personal and social development.

IC2013 Table 3 – Student Ranking of Personal Growth[3]



[2] The relative scale of the headlines signifies the level of importance in terms of student perceptions.
[3] The relative scale of the headlines signifies the level of importance in terms of student perceptions.

IC2013 Table 4 – Student Ranking of Course Experience[4]



Community partners of the Public Design Service are selected with some necessary conditions: (a) they are not-for-profit organizations; (b) the communications or design needs of the community partner meet with the academic goals of the course; and, (c) activities to be undertaken are agreed to be of value to both parties. During the last three years, 44 not-for-profit organizations were clients of the Public Design Service. See Table 5 – Public Design Service Clients 2010-2012. Most students invested in excess of thirty hours outside of classroom time into their various projects. Another 20% of respondents indicated that they spent in excess of 40 hours on this activity. In responding to the question of whether the experience has a positive impact on the organization, 85% of community partners reported that the experience had either a positive or very positive impact. Approximately 10% of community partners reported a neutral impact and less than 5% reported a negative impact.[5] Of the student respondents, 75% felt that their work had a positive or very positive impact on the client and 25% felt their work had a neutral impact. Further research is required to examine the neutral and negative groups more thoroughly.

IC2013 Table 5 – Public Design Service Clients

	2010	2011	2012
Alberta Civil Liberties Research Centre	Event Poster	Poster, Book Cover	Cover for DVD, Guidebook, Poster for 30th Anniversary
Alberta College of Art and Design	Public Design Website		Show and Sale Rebranding, Promotional Materials
Alberta College of Art and Design Faculty Association			Website Redesign
Alberta Cops	Recruitment Elements for AC Website, Exhibit, Video		
Alberta Magazine Publishers Association			
Alzheimer Society of Canada	Corporate ID		
Calgary Car Share	ID Package		
Calgary Centre for Global Community	Display, Brochure, Program Brochures, Banner		
Calgary Drop-In Centre			Play it Forward Program
Calgary Educational Partnership Foundation			Logo, Tagline, Application Guidelines, Collateral Materials
Calgary Food Bank		Logo, ID Program, Applications Corporate Manual	
Calgary Humane Society		Advertising Campaign – Posters and Billboards	
Calgary Opera			Premier Gala Invitation and Collateral Materials
Calgary Outlink – Centre for Gender and Sexual Diversity	Website		
Calgary Philharmonic Orchestra	Poster, Postcard, Business Card		
Calgary Public Library Foundation		Logo and ID Program	
Calgary Seniors Resource Centre		Recruitment Brochures	

[4] The relative scale of the headlines signifies the level of importance in terms of student perceptions.
[5] Respondents indicating a negative impact were due to one of the following; a miscommunication at the outset of the project regarding scope and nature of work required; project parameters being altered midstream; or a student refusing to address the client's needs.

Cerebral Palsy Association in Alberta		Gala Invitations, Tickets, Web Graphics, Programmes	
Central Alberta Aids Network Society	Website, ID Package		
Centre Stage Theatre Company	10th Anniversary Season ID, Brochure		
The Children's Link Society			Logo, Stationary, Brochures, Website, Social Media
Community Wise Resource Centre			Poser Design, Community Forum, online and print
Epcor Centre for the Performing Arts	Annual Report		
Fort Calgary		Interior Map, Exterior Map	
Kids Cancer Care Foundation			Poster
Green Calgary		Advertising – Poster Campaign, Website	
Library Association of Alberta			Logo, Identity Manual
The Military Museums		Research	Advertising, Rebranding of Lecture Series, Educational Brochures, Exhibits Page, Integrate Social Media
Missing Children Society of Canada	Logo for 25th Anniversary		
Provincial Health Ethics Network	Brochure, Catalogue		
Rosebud School of the Arts		Website, Poster, Brochure	
Rhythmic Gymnastics Alberta			Logo, Website
Seeds Foundation		Website	
Sexual and Reproductive Health Program - AHS		Logo Design, Applications Corporate Manual	
Sheldon Chumir Foundation	Event Poster, Event Template, Book Cover		
Society of Graphic Designers of Canada	Portfolio Show Poster	Portfolio Show Poster	Portfolio Show Poster
Sustainable Alberta Association		Poster, Website Graphics, Flyers, Booklet	
Triwest Soccer			Logo, Collateral
Vecova Disability Services		Logo, Program Development	
The Vocational and Rehabilitation Research Institute	ID Package, Branding Guidelines		
Volunteer Alberta		Print Collateral Material	
WP Puppet Theatre Society			Logo, Branding, Postcard
Work of Your Hand International Development		Posters, Brochures, Label Designs	
Youths Can Fish 2 Charity	Poster		

Conclusion

As service-learning is not a traditional learning experience in the context of design education it can pose challenges to the community organization, the service-learner and the faculty with respect to the most fair and effective way to evaluate the student academically. In many cases the success of a service-learning project depends on the level of commitment made by both the representatives of the academic institution and the community partners to developing and carrying out a successful project. The effectiveness of the communications between parties prior to and during the project, and the compatibility of the student and the recipient organization are key factors here. It is critical to anticipate the individual students' constraints in terms of previous knowledge, skills, and experience. It can also be challenging for the student designers who are required to work with a wide range of people who have strong opinions and a lot of pride and emotion invested in their organization.

Partnerships with community organizations can also be complicated due to the disconnect between the academic world's time frame and culture as well as the specialized lingo associated with design work. At times, it can seem as if the two parties are speaking entirely different languages. In order to mitigate this issue, both parties need to openly discuss the nature of the partnership, how to manage the relationship and clearly define the outcomes. It is also vital that a process for responding to the other's concerns be established. This allows both parties to clarify their expectations as well as their roles and responsibilities in the learning process. In addition, the better the faculty's understanding of the community partner's organization and processes, the better the service-learning partnership is for all parties. Though the bulk of this process occurs at the outset of the service-learning partnership, it is crucial that there are regular updates and continued communication throughout the process. Clients need to understand the unique nature of service-learning, be willing to work with students, be willing to be educated in the design process. In short, they must understand the relationship between their project goals and the learning outcomes for the students. Students need to understand and accept responsibility for their role and actions as a designer, understand design as a profession, and must be open to a non-traditional learning experience. Faculty must

be able to assess projects for their suitability vis-a-vis course learning outcomes and maintain objectivity between client and classroom.

Within the context of the Public Design Service concerns around miscommunicated expectations and the consequences that can result are addressed by setting out an explicit agreement between the organization, student and faculty in the forms of a letter of agreement, a design brief and a contract. Faculty facilitate this process with the students through lectures, panel discussions and one-on-one meetings, as well as through discussions with the client prior to student assignment. Students are encouraged to initiate a formal process with the client to further communicate and develop agreement on the expectations. An important component of this relationship is the nature of the communication between the community organization and the higher education institution representatives, which can differ depending on the structure of the community organization and the size and nature of the project at hand. It is important to create more and better communications without overburdening the student, faculty or community partner. The faculty role in this experience needs to be differentiated from other teaching methods. Here the real-life experience is paired with a more open learning method where faculty take a less directive role in favor of a more facilitative one. Assessment of learning outcomes can be much more challenging in this type of teaching method where there is a much greater potential for variation in service experiences and some loss of control over student stimuli. However this can be mitigated by creating assessment criteria on assessable artifacts.

Implementing and maintaining a strong and relevant service-learning program requires a great deal of time on the part of the institution and faculty to manage both community partners and students. The very nature of service-learning is such that all stakeholders – communities, faculty, students, institutions and policy-makers – are all impacted by the purpose, assumptions, and practices of various service-learning initiatives. (Chambers, 2009. P.90) These types of initiatives require planning, networking skills, organizational capabilities and sometimes a significant time commitment on the part of the institution and the faculty responsible for the course or activities. Despite the many challenges service-learning by almost any measure has been an enormously successful academic innovation (Stanton, Giles, and Cruz, 1999).

From an institutional standpoint service-learning can address imperatives such as: What is responsibility of the institution as part of the community; What is the role of higher education in terms of civic and social engagement; and, How does the educational experience demonstrate value to the external community. For post-secondary institutions, service-learning initiatives provide additional means of demonstrating the value of investing public investment in post-secondary education. When done well, such initiatives present the institution as a positive and contributing member of the community and give substance to the rhetoric of partnership and outreach. (Chambers, 2009, p.93) Service-learning can build strong links between institutions and a wide range of communities and while preparing students to be socially engaged individuals.

Combining service-learning with design education can have significant benefits for individual students, the institution, as well as the external community. On the individual level, this type of learning experience can increase confidence, fostering leadership and business skills. It also enhances skills in project and time management, as well as communication. Students have the opportunity to use their experiences of helping not-for-profits strengthen their understanding of design practice which in turn encourages the development of knowledge, skills and values. It can allow the student to apply academic knowledge to real-life problems and through their service-learning experience, students can develop a greater sense of civic and social responsibility. In addition, the material students produce through this experience can and do have positive effects on both their target audiences and the community as a whole. On the institutional level, this type of initiative promotes community outreach and may demonstrate credentials and value to the community at large. On a community level, service-learning can produce a greater sense of civic responsibility and utilizes students' creativity as a resource to provide a needed service for a not-for-profit community partner. Despite the challenges of incorporating project-based service learning in design education service-learning has the potential to be a positive experience for all stakeholders, encouraging new ways of thinking, doing, and acting with respect to civic engagement.

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Author Biography

Alison Miyauchi is the Chair of the School of Communication Design at the Alberta College of Art and Design, where she researches and teaches in the areas of graphic design and design education. Alison Miyauchi is a graduate of Bryn Mawr College, Pennsylvania and a former Research Fellow in Architectural History and Historic Preservation at the Smithsonian Institution, Washington, D.C.
alison.miyauchi@acad.ca

Innovation through Lean Efficiency: Benefits and Barriers for Graphic Communications Companies

Josh Ramsbottom[1], Ken Macro[2]
[1]NorQuest College, [2]California Polytechnic State University

josh.ramsbottom@norquest.ca, kmacro@calpoly.edu

Keywords: Lean Manufacturing, Commercial Printing, Implementing Lean, Barriers, Benefits

The objectives of the presentation are to describe the activities undertaken with graphic communications firms in Western Canada relating to the establishment of Lean efficiencies. Lean organizations strive to reduce costs through waste reduction; i.e. inventory reduction, work-in-progress reduction, and misappropriated labor. Additionally, Lean organizations aim to increase on-time delivery and efficiencies associated with production and improve value add processes for customers while reducing wasteful practices.

This presentation will describe preliminary results of the benefits and barriers of implementing customized Lean efficiencies in small and medium sized enterprises in Western Canada. We engaged four companies of various sizes in Western Canada to develop realistic customized Lean implementation plans and will present on the three and six month outcomes of each company.

Initial findings on the barriers companies face implementing Lean practices indicate that while all are highly reliant on the technological printing process, none have a full understanding of the daily operational workflows taking place within their plants. This is indicative of processes and workflows that developed organically and not through detailed planning. Another common barrier is the difficulty in changing corporate culture to sustain Lean initiatives and goals. A final identified challenge this research has shown to date includes a lack of detailed metrics in the companies prior to Lean efficiency implementation making it very difficult to quantify monetary benefits Lean programming has within small and medium size companies in the short term.

A selection of the positive early findings at individual firms as a result of the Lean planning will be reviewed. For example: a company eliminated 25% of the space the shipping receiving department had allocated because it was found to be holding waste and unneeded equipment. That space has now been repurposed to revenue generating activities. Consequently a cleaner and more organized space eliminated the need to double handle jobs and inventory allowing one shipping position to be made redundant in the area and in keeping with Lean best practices, the redundant person was reallocated within the company to another area with revenue growth potential. A second company involved in the program estimated returns of over $8,000 in catching production errors before they happened using Lean processes and in the selling of unneeded equipment within 3 months of starting Lean activities in their plant.

The presentation will conclude with a discussion of some of the knowledge acquired by individual firms involved with the project, such as: knowledge transfer between manufacturing plants and teams, elimination of waste, employee safety and moral, communication between managers and employees, managing and discipline in process flow changes, and improved customer experience.

The changing playing field for graphical companies and education in The Netherlands

Erik Stevens, Henk Vermeulen

Erik Stevens GOC Netherlands
Henk Vermeulen GOC Netherlands
e.stevens@goc.nl
h.vermeulen@goc.nl

Keywords: Print Industry, Creative Industry, Graphical Companies and Education.

'If we don't change direction, we might end up where we're heading!' Yes, change is not always convenient but it certainly is necessary, and at times it can even be refreshing. Change makes us more creative, alert and able to make better choices and decisions. The graphical industry (companies and educational institutes) should realize that it no longer stands out as a more or less independent industrial segment, but that it's part of a broader creative industry.

The creative industry is one of the top industries in The Netherlands. An industry becomes a top industry when the industry is knowledge intensive, export oriented, economically interesting, essential for the solution of social issues and knows specific laws and regulations. The creative industry makes a significant contribution to the Dutch economy, creating about 3% of NL GNP and employing about 172.000 people in 97.000 companies. In addition, the sector plays a crucial role in innovative developments and preserving cultural heritage. The Creative industry is booming and growing faster than any other industry. Therefore it is the Dutch government's vision and ambition to be the most creative economy of Europe by 2020.

The creative industry consists of different sectors and one of them is the print industry (despite the fact that these companies do not realize this as yet). Unfortunately, due to fast developments such as Internet and digitalization the print industry has been shrinking over the past few years and expectations are that this will continue to happen. Graphical companies are trying hard to remain profitable and react to the structural changes and the crisis by focusing on improving their efficiency, cutting labor costs and investing in higher productivity (machines).Despite their efforts, numbers keep dropping and costumers stay away. It is clear that graphical companies adopt the wrong strategies with their focus on only efficiency and productivity. In our opinion these companies should start to redefine themselves by acknowledging that they are part of a broader spectrum; the creative industry.

Parallel to the shrinking market for graphical companies, we also encounter shrinkage in the graphical education. The amount of students enrolling for these studies continues to drop every year. Educational institutes have the tendency to react by focusing on internal issues, improving output (diplomas) and restructuring procedures, e.g. to improve collaboration. In our opinion these institutes need to focus on the right things and create more added values for the students (new services). One of these services is providing facilities for "life long learning".

Our conclusion is that both graphical companies and graphical educational institutes have to adapt to the new reality. We are speaking about a reality that asks for new strategies and the development of new (creative) services. A reality in which the production machines (press and after-press) evolve from offset and high volume to digital and low volume. A reality where technological topics need to be placed in a creative context. A reality in which communication does not always follow the road of print, but uses many pathways, sometimes paper, sometimes digital (web, social media, etc.) and most times a combination of both. A reality that asks for different educational focus: from the temporary classroom to the permanent facilitation of life long learning. If graphical companies and graphical educational institutes successfully adapt to this new reality, only then they will be able to survive and thrive!

Erik Stevens
Chairman of the Board, GOC

Henk Vermeulen
CEO, GOC

Renewing a Graphic Arts Curriculum: Planning for the Future

Ian Baitz [1], Jason Lisi [2]

[1,2] *Ryerson University, Canada*
ibaitz@ryerson.ca, jlisi@ryerson.ca

Keywords: Curriculum, Education, Student Engagement, Curriculum Mapping, Pedagogy.

Abstract

The last decade has brought about extensive change in the way the printing industry is defining and delivering its end product. The tradition of ink on paper has morphed into something many would not have anticipated even 20 years ago. Graphic arts programs must keep their curricula current, relevant, pedagogically proficient and economically feasible in order to meet the needs of industry and students. Not only do educators need to ensure topics are relevant for today's print market, but they also have to be able to anticipate the future and be able to adapt curricula to meet future needs.

At Ryerson University, the School of Graphic Communications Management (GCM) is in the process of a major curriculum renewal that is anticipated to be complete in 2014 for implementation in 2015. A curriculum committee composed of students and faculty members is undertaking this major work.

Several factors led the School to embark on such a major curriculum revision. First among these is a university-wide curriculum renewal white paper. This document outlines a new framework for how curriculum is delivered across the university. Major goals are increased student choice, expanded opportunities for experiential learning, improved access to minors and the introduction of double majors (Ryerson University, 2012).

The curriculum revision is also in response to changing industry needs and the responsibility of educators to ensure students are equipped with skills required by the printing industry.

There are many important stakeholders in a graphic arts curriculum. They include students, industry, the university, faculty members, and others. Central to the School's curriculum revision is improving the student experience with a relevant, modern curriculum. It is expected that student surveys including the National Survey of Student Engagement (NSSE) will reflect the strengths of an improved graphic arts curriculum from the perspective of students. Additionally, the appeal of the graphic arts field to potential future students must be considered.

The curriculum revision is also related to institutional quality assurance. In 2014 the School will undergo a Periodic Program Review (PPR) which will include a critical analysis of the curriculum. There are clear synergies between curriculum renewal and ongoing program review.

This paper discusses the process undertaken by one School, and in particular its curriculum committee, to develop the most comprehensive overhaul of its curriculum in over 20 years. As well, it identifies challenges that must be considered in the present post-secondary environment, including limitations on budget, physical space and other resources. These challenges call for an innovative and flexible approach in responding to the future curricular needs of students and all stakeholders for the future of a dynamic and evolving graphic arts education.

Background: The Graphic Communications Management Program at Ryerson University

The School of Graphic Communications Management at Ryerson University in Toronto is the only university program of its kind in Canada. The program is a print-centric business management program that emphasizes the importance of business management functions while teaching the technical aspects of software and equipment one would expect to find in the graphic communications industry. While Ryerson's GCM program is unique in Canada, there are several comparator schools that can be found in the United States and elsewhere internationally. Ryerson is fortunate to collaborate with many of these institutions at various levels.

The Ryerson GCM program has a long history. GCM was one of the founding Schools (departments) at Ryerson, and has been in operation for 65 years. As can be expected, the School has responded and adapted to

change of the past six decades, and has done so successfully. Despite having more than doubled first year enrolment over the past ten years, GCM graduates are still successful in the employment marketplace. This is in no small part due to the relevance of the curriculum.

While GCM has done a good job at maintaining currency in its courses, the structure of the curriculum has not changed in many years. Further, over the last decade, the vast majority of curricular development was done by instructors at the course level. There is a need for holistic discussions about curriculum across the School as a whole. Given this reality, along other mitigating factors, the timing was right for the School of Graphic Communications Management to explore a major revision to its curriculum.

Curriculum Revitalization

The Favourable Conditions for Curricular Revitalization

There were several separate and unique factors that, when combined together, created the perfect window of opportunity for GCM to consider a significant change to its curriculum:

1. GCM is a School (department) within the Faculty of Communication and Design (FCAD) at Ryerson University. GCM is currently the only School in the Faculty where students have no choice in the professional core of the program. In other words, every core course within GCM is compulsory. This makes GCM anomalous with the rest of the Schools within the Faculty.
2. The GCM program is also the only program without choice in the professional core when compared to major comparator programs in graphic communications (e.g. Clemson University, Rochester Institute of Technology, California Polytechnic State University, Western Michigan University, as well as comparable European programs). Therefore, not only is GCM anomalous within its Faculty, it is also anomalous when compared to other graphic communications programs.
3. Minor curricular modifications within GCM over the years have resulted in the program having a number of courses with non-standard course hours (one and a half or two hours per week, versus the Ryerson norm of three hours per week). This creates problems with scheduling and course assignment.
4. A new Creative Industries degree program that is launching in FCAD in Fall 2013 will offer opportunities for collaboration with GCM. This opportunity, along with changes to our Certificate offered through Continuing Education and aspirations of having a Minor also strengthen the impetus for curricular change.
5. In June 2011, the approval to explore a new University-wide curriculum framework at Ryerson was given, which led to the formation of the Curriculum Renewal Committee (CRC). In June 2012, the CRC outlined a new curriculum framework in a white paper was subsequently approved by Ryerson's Senate. In May 2013, the same committee released a green paper that further discusses how these curricular changes will be implemented across the University. Ultimately this means that every School within Ryerson is going to have to consider its curriculum at some point in order to ensure compliance with the new model. For GCM, it made sense to consider a major curricular revitalization at a time when the University as a whole is rethinking curriculum.
6. Every seven to eight years, programs at Ryerson University undergo a Periodic Program Review (PPR) as part of the Institutional Quality Assurance Program (IQAP). This is a comprehensive review of the program, its goals, and how it is meeting the requirements of a degree program. As part of this process, each School must undergo a comprehensive self-study and external examination of its curriculum. The steps involved in doing this are practically identical to the steps involved in reviewing curriculum on the premise of curricular change. Since GCM is slated for PPR in 2014, the timing to undergo a major assessment of curriculum is ideal.
7. The graphic communications industry is constantly changing. While the School has done a good job at remaining current with the topics it currently teaches, there is a sense that there are topics which many in the School would like to cover in more depth. The curriculum must be able to keep up with the changing needs of industry, and must be flexible enough to be able to adapt to new changes as they arise. In other words, a well-planned curriculum will be able to easily meet the ongoing evolution of the graphic communications industry. The current rigid curricular framework makes this somewhat difficult.
8. The GCM program at Ryerson has had significant growth with a present student population of over 500 students (expected to grow to 600 within 3 years) compared to only 250 students 15 years ago. The

curriculum model that worked 15 years ago with 250 students may not be the ideal model for a larger School today and in the future.

Theoretical Underpinnings

In approaching curriculum, it is necessary to consider theoretical underpinnings. Very few topics in education have been as thoroughly researched and described as curriculum.

Throughout its work, the GCM Curriculum Committee was informed by the Curriculum Renewal at Ryerson University white paper. This document, developed by a committee of internal experts who served in working groups, offered 19 recommendations to the University Senate on the issue of curriculum structure within the university (Ryerson University, 2012). It also identified the following four guiding principles:

1. Student flexibility to define their educational and career goals, and therefore increased student curricular choice.
2. Programs must maintain sufficient rigour and depth to ensure that Ryerson's mission of career-relevant education is served.
3. Graduates must be well rounded, with a breadth as well as a depth of knowledge.
4. Quality Assurance processes must be respected, and educational objectives, including critical thinking and communication skills (particularly writing), must be met.

Before examining the state of the Curriculum Committee's work on curriculum renewal as directed by the white paper, it is wise to consider some of the theory on curriculum.

The Current State of Post-Secondary Curriculum

The respected curriculum expert Robert M. Diamond (2008) aptly makes the point that curriculum structure is often in a state of disarray.

> The observations identified in the Association of American Colleges and Universities' report, *Integrity in the College Curriculum: A Report to the Academic Community* (1985), are even more appropriate today than they were over twenty years ago: "As for what passes as a college curriculum, almost anything goes. We have reached a point at which we are more confident about the length of a college education than its content and purpose. Indeed, the major at most colleges is little more than a gathering of courses taken in one department, lacking structure and depth … or emphasizing content to the neglect of the essential style of inquiry on which the content is based …". The report continued, "The curriculum has given way to a marketplace philosophy; it is a supermarket where students are shoppers and professors are merchants of learning. Fads and fashions, the demands of popularity and success, enter where wisdom and experience should prevail.

While the committee was hopeful that the existing curriculum in GCM is somewhat more deliberate and purposeful than Diamond reports about curricula in general, the point was accepted that a deliberate, well-considered structure is necessary.

Diamond also makes the point about the "marketplace philosophy" whereby students might choose courses based on popularity, fads or other superficial factors. This is an important point to consider, especially since the Ryerson Curriculum Renewal white paper identifies student flexibility and curricular choice as its first guiding principle. Susan Toohey (1999), who emphasizes the importance of an integrated (or program-wide) curriculum, addresses this apparent conflict between the trend toward increased student choice and the importance of a planned, structured curriculum. She writes, "This may seem an anachronism with the advent of modular courses. But ceding more responsibility to students for structuring their own education requires greater clarity about what each module can offer and how they might be linked together to form a coherent whole" (Toohey, 1999).

Understanding Curriculum and Pedagogy

Educators frequently use the terms "curriculum" and "pedagogy." In some cases the terms are used almost interchangeably. The understanding and interrelationship of curricula and pedagogy have changed over the years and remain in flux. Posner and Rudnitsky (1980) provide a rather strict definition of "curriculum." They write, "'Curriculum' represents a set of *intentions,* a set of learning outcomes. Consequently, curricular matters have to do with the nature and organization of those things we as course planners want learned in our courses." They identify as distinct the curriculum – what is to be learned, or learning outcomes – from an instructional plan, which is how the curriculum will be taught. (Posner & Rudnitsky, 1980).

On the other hand, there are experts who would not make such a clear distinction between curriculum and an instructional plan, or pedagogy. For example, the OECD (1990) posits that "curriculum" and "pedagogy" are sometimes used flexibly and ambiguously, and are not always well-defined. In attempting to clarify somewhat, the OECD (1990) offers the following, "Curriculum will thus necessarily include goals, values and modes of activity thought to be appropriate or necessary in order for desirable learning to occur." In contrast, the same report states, "Pedagogy is in the translation of curriculum into the operations of teaching, and learning is sometimes equated with method, predicated upon a traditional distinction between curriculum as 'content' and pedagogy as 'delivery of content.'" (OECD, 1990).

Therefore, the Curriculum Committee had to consider whether to examine only curriculum in stricter sense of "content" or also to concern itself with how that content is delivered, pedagogy. Research suggests that while, to some, curriculum and pedagogy may be seen as distinct, even to those who hold to the more traditional definitions, any examination of curriculum must also consider pedagogy or the instructional plan. For example, the traditionalists Posner and Rudnitsky (1980) offer the following useful chart which shows the direct relationship between curriculum and the instructional plan.

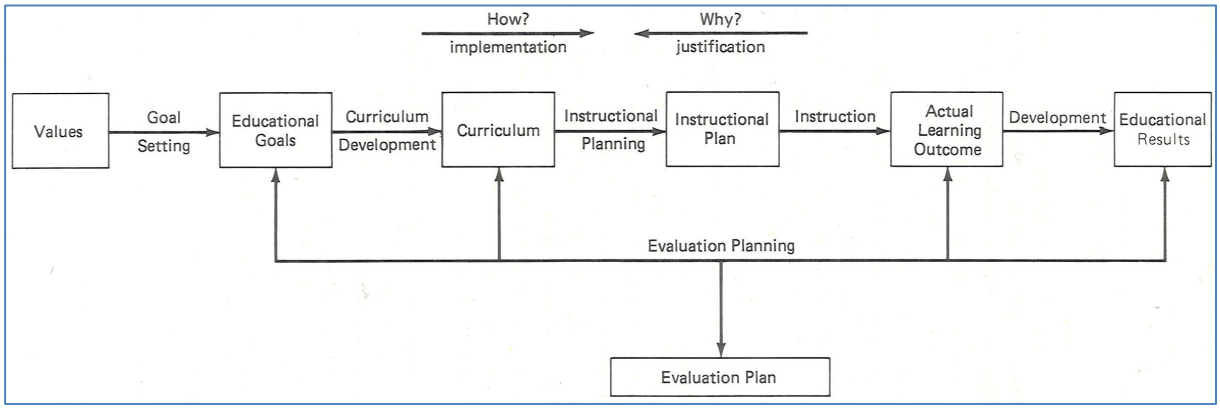

Figure 1. Posner & Rudnitsky's (1980) Curriculum Instruction Model. Adapted from Johnson (1967).

In developing a curriculum and considering how to best teach that curriculum, the chart provided by Posner & Rudnitsky is quite useful. Even greater utility is provided by considering how to arrive at the increasing specificity or granularity which is required to move from broad goals to a specific plan. In the figure below, Posner & Rudnitsky (1980) add detail to their chart to show the relationship between a curriculum model and course design.

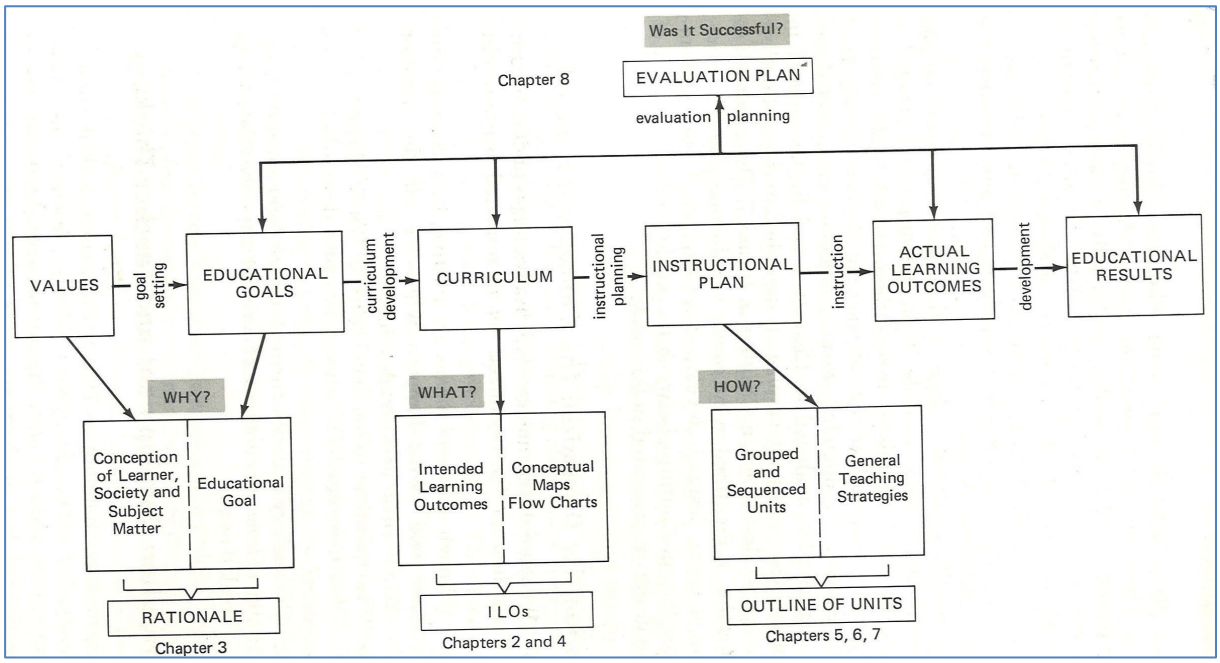

Figure 2. Posner & Rudnitsky's (1980) Relationship between the Model and Components of Course Design.

The conceptual framework illustrated above suggests that broad goals, curriculum, and the plan of how to deliver and teach a curriculum are rather inter-related. Diamond (2008) also presents a somewhat similar view of the relationship between elements of a curriculum model.

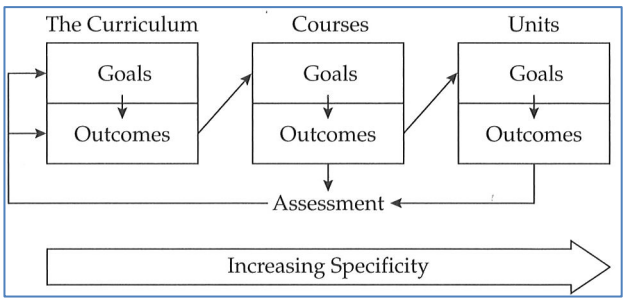

Figure 3. Diamond's (2008) chart: From Goals to Outcomes to Assessment.

In expanding on the relationship between goals, courses and curriculum, Diamond (2008) writes:

> As we teach our courses, we tend to lose sight of the fact that each course is but one element in a learning sequence defined as a curriculum. The closer the relationships are among courses, curriculum, and planned out-of-class activities, the more effective the learning experience will be for our students. So, whether you are working on the design of a single course or of a curriculum, it is imperative that you keep in mind the relationship between the two. A quality education does not happen by chance; it requires careful planning, skilled teaching, and an overall structure that ensures that every student has the opportunity to reach the goals of the program in which he is she is enrolled. A quality education requires a level of orchestration seldom found at colleges and universities as well as the active involvement of a faculty that is paying a great deal of attention to structure, content, and process.

There are a broad range of resources on curriculum research which reside within university libraries and learning and teaching offices. While a detailed study of curricular issues may not be necessary for every faculty member, teacher or administrator who is involved in a curriculum development or revision, at the least those leading such teams or initiatives should have a basic understanding of underpinnings in the literature and research of curriculum studies.

The central question to be resolved by the Curriculum Committee is, as Toohey (1999) put it, "What is most important for these students to know and what might be the best ways for them to learn it?" In pursuing the answer to this deceptively simple-seeming question, the committee sought to consult broadly with the various stakeholders in the program, and also to work within the governance structure of the university.

Approval Structure for Curricular Change at Ryerson University

Academic matters at Ryerson University are ultimately governed by the University Senate, the academic policy making body of Ryerson University. Within the Senate, there are several standing committees that carry out academic functions and responsibilities. For the purpose of this paper, one of these committees is important to identify: the Academic Standards Committee (ASC).

One of the major roles of the ASC is to review and approve significant curricular changes prosed by Schools. It is this committee's responsibility to ensure that that the changes proposed are appropriate, meet quality assurance and other academic requirements of the government and university, and can be implemented in a way that is appropriate.

Also significant to recognize is the role of School Council. School Councils at Ryerson University derive their authority through Senate policy. One responsibility of School Council is to govern department-level academic matters. The School Council is the School-level decision-making body on academic matters affecting the School.

With regards to the curriculum revitalization for GCM, the structure and flow of events are as follows:

- School Council, through a mandate of its members and in accordance with bylaws, constituted a Curriculum Committee, as a subcommittee of School Council.
- The Curriculum Committee steers the process of developing a new curriculum model using the methodology discussed later in this paper.

- The proposed changes are voted on in School Council. If successful, the plan will be forwarded to the Dean of the Faculty. If the Dean approves the plan, it will be forwarded to the Academic Standards Committee.
- The Academic Standards Committee will deliberate on the proposed changes, provide feedback and a recommendation or motion to Senate. If the proposed changes are approved by Senate, the changes may proceed.

The Process for Developing a New Curriculum in the School of Graphic Communications Management

The process for developing a new curriculum for the School of Graphic Communications Management began with the formation of a Curriculum Committee. The committee consisted of four faculty members, the Chair of the School, and two students. The committee met to choose a Chair, to discuss mandate and what steps would be necessary to carry out that mandate.

The work of the Curriculum Committee was extensive. The committee met every week for two hours beginning in September through the end of April. Between meetings, committee members were given tasks that had to be completed by the next meeting.

The Curriculum Committee decided early on that the best way to begin was to consult stakeholders internal to the University. The decision to do this was twofold: First, by meeting with internal stakeholders and discussing the committee mandate, the committee could get a sense of whether or not the mandate would be well received by the University. Second, meeting with University stakeholders provided information and guidance on how to best begin the process. As a result, the GCM Curriculum Committee met separately with the Vice Provost Academic and Chair of ASC, the Dean and Associate Dean of FCAD, the Executive Director of Undergraduate Admissions, the Director of Curriculum Quality Assurance, and the University's Curriculum Development Consultant.

The results of these internal stakeholder meetings were very positive. The representatives were supportive of the ideas the Curriculum Committee shared with regards to the proposed changes to GCM's curriculum. Furthermore, none of the stakeholders expressed any concerns with the rationale the committee presented as to why curricular change was needed, and similarly, all the stakeholders agreed that this was the right time to be making the proposed changes. The meetings also provided valuable guidance to the committee.

Based of the positive feedback the committee received from University stakeholders, it felt confident that the process could move forward as per the committee's mandate. The committee began two simultaneous work paths at this point. First, the committee began an extensive research and review process. This included a thorough review of the curriculum models of comparator schools. The committee felt this was important because it could identify positive aspects of different curriculum models and possibly apply those to GCM's new model. Also, as part of the research phase, the Curriculum Committee (with appropriate permissions) reviewed a recent curriculum revision proposal sent to the Academic Standards Committee. This was significant because it helped the committee understand the breadth and depth of detail needed in a proposal as significant as the one it was developing, and the feedback from Academic Standards helped the committee identify key markers that are required in a successful proposal.

In addition to the research phase just mentioned, the committee developed two strategies to consult with one of the most important stakeholder groups in this process – the students. First, with the help of the Curriculum Development Consultant in the office of the Vice Provost Academic, the Curriculum Committee conducted a focus group with fourth year GCM students. Facilitated by the Curriculum Development Consultant, the graduating class was given opportunity to candidly discuss what they liked, didn't like, and what they would like to see in the future with regards to curriculum. The feedback from this group was very important. As fourth year students in the last semester of their program, these students had had the full range of experiences that GCM offers. The second strategy the committee developed was a comprehensive online survey that was open to students in all four years of the program. Using the functionality of the survey software, students were shown a subset of questions from a master list according to their year of study. For example, a first year student was not asked questions related to a course offered only to second year students. This helped to keep the answers received relevant because students would not be able to offer an opinion on something they had yet to experience. The survey was completed by 200 GCM students.

On April 11, 2013 the Curriculum Committee made a presentation to School Council regarding its work to date, and shared the preliminary findings from both the fourth-year focus group and the online survey. Feedback from School Council was very positive. On the same day, the committee also hosted a town hall for students in order

to present the same information to the student body. The town hall was well attended, and again the feedback the committee received was very positive.

In May 2013, consultation with faculty within the School commenced. Again, with the help of the Curriculum Development Consultant, all instructors within the School were invited to work to develop a set of concrete goals for the School, and then turn those goals into learning outcomes. Once these learning outcomes were established, the faculty mapped the current curriculum to the learning outcomes to determine where each learning outcome was introduced, reinforced, and then taught to proficiency. Once the mapping was complete, the consultant again assisted to determine where there were concerns with regards to how the current curriculum addresses the program goals. In particular, areas where redundancy or omissions occurred were documented, as well as instances where a learning outcome may actually be reinforced before it is introduced.

The following section outlines the findings to date.

Preliminary Results, Findings and Outcomes

Student Consultation: Fourth Year Focus Group

The first consultation that occurred with students was the fourth-year students focus group. Approximately 10 graduating students met with the Curriculum Development Consultant to discuss the curriculum. Although this was a small and targeted consultation, the Curriculum Committee felt is was important for a couple of reasons. First, the fourth-year students have a unique and dynamic perspective of the entire program because they are close to completing it. They have experienced all the classes, assignments, internship preparation and completion, and the initial process of beginning a career. Second, the committee felt that there was a lot to be gained from a small focus group session with open dialogue that might not be captured in another data capture method such as an online survey.

At the onset, it was agreed that the consultant would lead the focus groups, and that no faculty would be present. The rationale for this decision is that the Curriculum Committee felt the students would be more open and honest then they would if the session involved faculty members that have taught the courses they might be criticizing. Overall, this proved to be a wise decision, as the students were very engaged and open about their experiences. The consultant wrote down the information the students provided, and reported anonymous aggregated data to the Curriculum Committee.

Overall, the graduating class identified faculty members, course work, internships, industry specific courses, and the overall community at Ryerson as things they liked. This can lead to the conclusion that overall the students are happy with the program, engaged in the course work, and that the faculty members, the School, and the University are doing a good job at maintaining a positive attitude amongst the students. The curriculum committee also considers this feedback to correlate to an overall positive attitude towards a connection to what is being taught and what industry is doing, since these students had completed their internship requirement.

Students identified for improvement the bridging between courses, some course content needing revision, and different professors teaching the same components of the same course. Although at first this may seem minor, some of these issues were considered to be significant by the Curriculum Committee. For example, faculty may assume that a prerequisite course is preparing students for an advanced course when in reality there may be gaps in the curriculum that lead students to struggle and faculty members to become frustrated. Similarly, two instructors teaching two different courses may understand how their two courses are linked to one another, but this message may not be clear to all students. The issue of two or more professors teaching different sections of the same course is also significant. A structured curriculum will assist with how to best deal with this issue pedagogically. For example, is a need to ensure that different sections of the same course are being taught the same things, in the same way, at the same level.

Student Consultation: Online Survey

Shortly after the fourth-year focus group was completed, the Curriculum Committee launched an online survey powered by Opinio, a sophisticated survey platform integrated with Ryerson's Central Authentication Service (CAS). There were several benefits using Opinio as the survey platform. For one, the integration with the Ryerson CAS restricted access to the survey to only members of the Ryerson community. In addition, Opinio allowed for question mapping based on decision trees. As mentioned earlier, this enabled the software to include or omit questions based the participant's year of the program, eliminating skewed results that can occur when a student answers a question to which he/she has no knowledge. The survey was 31 questions in length, although the total number of questions a student answered varied based on the decision tree model just mentioned.

The online survey allowed the Curriculum Committee to better understand the views and opinions of current students in all years. Using a combination of multiple choice, multiple answer, scale, and freeform text questions, the committee was able to gather very useful data from this survey. There were 200 participants who completed the survey, with almost half of the participants (46%) from the first year cohort.

Table 1: Survey Participants by Year of Study

Year of Study	Absolute Frequency	Relative Frequency
Year 1	92	46%
Year 2	51	25.5%
Year 3	29	14.5%
Year 4	26	13%

Based on an analysis of the survey results it is fair to say that students feel most of the courses taught at GCM have struck the right balance in terms of technology and business. Most perceived a good balance between lecture and lab time, but a number identified a need for more lab time and less lecture time. As with the fourth year consultation, students that completed the online survey indicated that they liked the internship component of the program, and that they were employable after graduation.

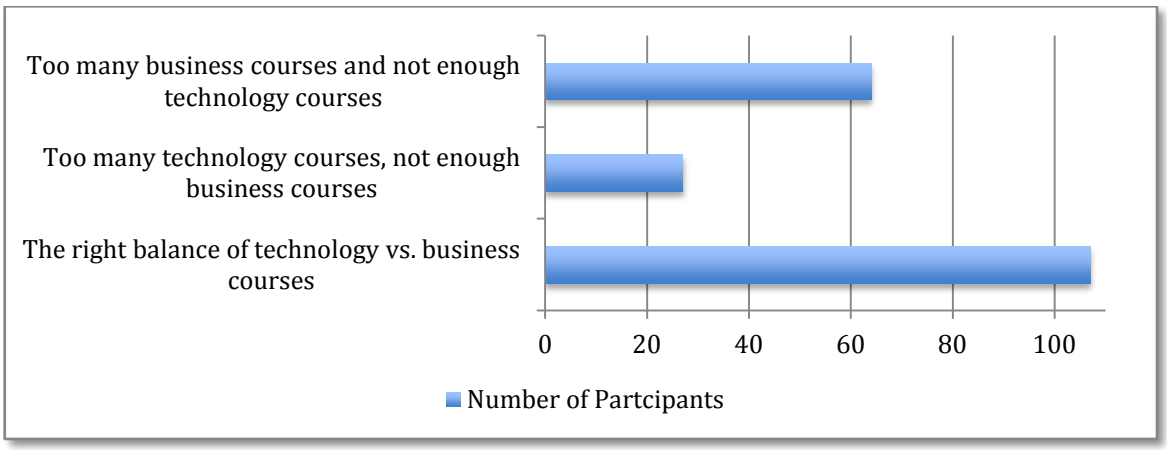

Figure 4. Balance of Technology Versus Business in GCM Program

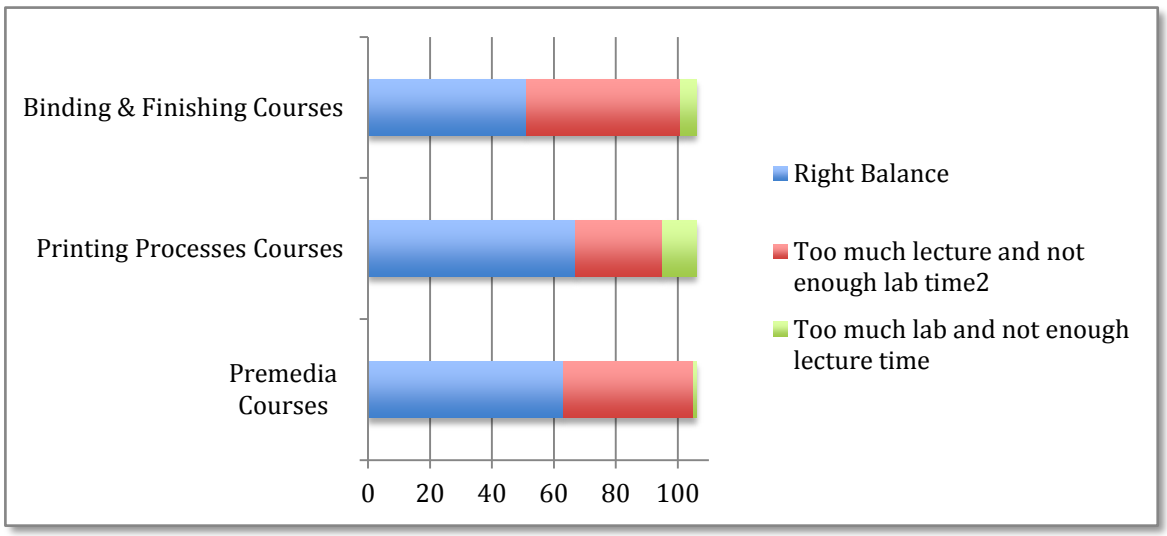

Figure 5. Balance of Lecture Versus Lab Time in GCM Courses

In addition, analysis of the survey data identified some key themes worth noting:

1. Students want more flexibility in choosing their courses. This result was not surprising to the committee. As mentioned earlier, GCM has the least amount of electivity of any program within FCAD or our comparator schools.
2. Students also indicated they wanted more choice when it came to the mandatory internship requirement. In particular, the ability to take internship in the fall, winter, or spring/summer semesters was very popular, as was the idea of receiving course credit for internship. Some students also showed interest in the possibility of taking internship in other years, not just third year.

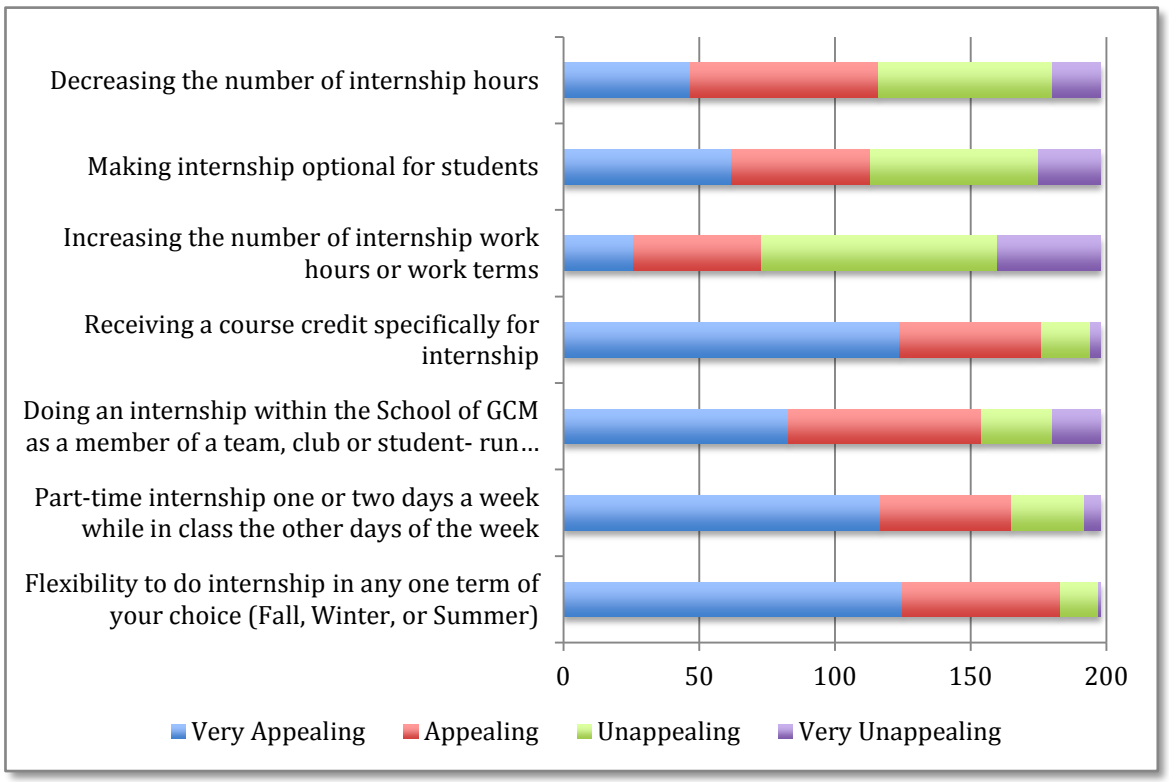

Figure 6. Balance of Lecture Versus Lab Time in GCM Courses

3. When asked if students would be interested in a co-op education option as an alternative to internship for a select small group of students, the response was very positive. The co-op model presented in the survey would alternate between teaching semesters and non-teaching semesters over a five-year period. In total, 77% of survey respondents felt co-op option was a very good or good idea.
4. In addition to wanting flexibility in choosing core courses, students also showed significant interest in a curricular model that included concentrations. For example, the first two years of the program might be common to all students, but then students would choose one or more streams of interest (which could include such themes as digital printing, premedia, packaging, etc.).
5. Although the vast majority of survey respondents indicated that they had not completed a full (one semester) online course, 49% of the participants said they would definitely or probably take GCM courses online if they were offered. Again, this suggests respondents favoured flexibility.

While the survey was valuable in identifying key curricular challenges, there were also some peripheral findings that the survey data found:

- A number of students have serious misconceptions about the current and future state of offset printing. Some referred to it as out-dated and no longer relevant when in reality it is the major printing process in Canada. This is a concern for a School whose key focus is printing.
- Students indicated that they would like to have more graphic design brought into the curriculum.

- There was some interest in having courses that cover the full spectrum of a printing technology as opposed to the School's current model of separating courses by function. For example, currently there is a course for layout and typography for all types of print, a course on prepress for all types of print, and then a printing course and a binding/finishing course. The alternative suggested would to be have a course that focuses on one printing process (e.g. lithography), and that course would cover everything from design through to printing or finishing. This model is seen at some comparator schools.

Faculty Consultation: Curriculum Mapping

In May 2013 the GCM faculty met in a series of day-long meetings in order to identify program goals and convert them into learning outcomes. The learning outcomes were then mapped to current course offerings to see where those outcomes learning outcomes were being introduced, reinforced, and then made proficient. This was a significant undertaking and the Curriculum Development Consultant provided significant support and guidance throughout this process.

In total, the School was able to break down learning outcomes into the six broad categories of Technology, Technical, Business Management, General and Academic Skills, Communication, and Self-management. In total 31 learning outcomes, plus some sub-outcomes, were identified.

Using a proprietary software program called Curriculum Assistant (CASST), faculty and instructors were able to map each learning outcome to courses they had taught in terms of introduced, reinforced, or proficient. When the process was complete, the results were set up in an easy to read table that visually mapped the current GCM curriculum to the learning outcomes the School had identified.

The results of the mapping were quite interesting. For example, some learning outcomes were actually being reinforced in some classes before they were introduced. A few outcomes never went past the reinforce stage.

There were also broader implications that were evident in the mapping exercise. For example, it became evident that GCM students tend to learn specific technologies that are important to our industry only once or a small number of times, yet they are expected to be proficient at it. For example, Adobe Illustrator is only formally taught in first year, while asset management is taught in fourth year. It was also evident that students are not getting enough experience with industry-specific tools and machines, broadly speaking, in the labs.

Another significant finding that came out of the mapping exercise is a concern that first year students are asked to manage a heavy and diverse workload. It is as if the majority of themes and concepts that will be covered in the four-year degree are introduced in the 24 weeks of class in first year. Additionally, it became evident that although students felt there is a right balance of technology and business within the program, the distribution of how it is taught is uneven. The technology component of the program starts out quite dominant in the first two years of the program, and steadily declines after that. In contrast, the business component of the program is more significant in the two senior years than it is in years one and two. Related to this is a sort of inverse emphasis in the GCM curriculum where there is a strong emphasis on core courses at the beginning of the program that declines over time, and little emphasis in the beginning on professionally related courses and liberals, with a steady increase over time. This trend is opposite of one would expect, as the professionally-related and elective courses are intended to build the skills and experiences needed as foundation for the core competency courses.

Further Considerations

This paper describes the theoretical and practical underpinnings of a particular curricular initiative at Ryerson University in the School of Graphic Communications Management. Because this curricular undertaking remains a "work in progress" there is an opportunity for additional scholarly research and further papers on the topic.

The Curriculum Committee will have many additional steps to undertake to complete its work. Those include a more detailed examination of comparator schools, ongoing consultation with stakeholders which will be expanded to include the industry and alumni. It will be necessary to clearly map curriculum to University Undergraduate Degree Level Expectations (known as UUDLES) before proceeding through the necessary draft revisions, re-consultation and approval processes.

The intended goal of the Curriculum Committee is to continue with its development of a renewed curriculum to meet the needs of students, industry and all stakeholders, and to respond to the curricular direction of the University. In this regard, the examination of comparator programs, survey and focus group data and faculty member input is essential. With consideration of curriculum theory and best practice, there is potential for a renewed, responsive and engaging curriculum which will benefit students, industry, faculty and society.

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Author biographies

Ian Baitz *is an Associate Professor and Chair of the School of Graphic Communications Management (GCM) at Ryerson University in Toronto Canada, and himself a graduate of the same program. In addition to being a strong enthusiast of graphic communications, he is particularly interested in education and pedagogy. His background in the education field includes a Bachelor of Education from the Ontario Institute for Studies in Education (OISE) at the University of Toronto and a Master of Education from the University of Southern Queensland (Australia). He has additional educational qualifications from Canada's Department of Transportation (Aviation branch) and the Canadian Forces. He has served on the Senate at Ryerson University and is a member of the University's Academic Standards Committee.*

Jason Lisi *is an Associate Professor in the School of Graphic Communications Management at Ryerson University, and the head of the School's premedia department. Before joining Ryerson in 2003, Jason worked several years in the prepress industry. Jason is active in several industry organizations, such as Magazines Canada (www.magazinescanada.ca) and the Ghent Workgroup (gwg.org). Jason holds an M.Ed from the University of Southern Queensland in Australia. Jason is a regular contributor for Graphic Arts Magazine, and he has written several peer-reviewed papers and presented at a variety of conferences.*