

# Optics, arts, and history continued: interaction with new master's degree program in electrical engineering

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## ABSTRACT

The present paper is understood as a short manuscript to a graphical poster. It is a follow up to a recent paper on a project in arts and science with the privately owned Museum of Future in Berlin and the Foundation for German-Polish Cooperation, which was celebrating 100 years of Kaluza's 5<sup>th</sup> Dimension in a geographically distributed interactive hybrid exhibition. The co-operation was continued and became inspirational for the students of a new master's degree program in electrical engineering. In the first group of students several student papers were involved in and inspired by our projects and delivered input. Two master's theses in progress are directly linked to the arts science topics. We demonstrate the surprisingly motivating effect of art projects on design and choice of topics by students, especially working part-time students.

**Keywords:** optics and arts, history of science, occupational safety, polarization, luminescence, paintings, glass and glazing colors, student projects

## 1. INTRODUCTION

In 2021 we started a co-operation with the privately owned Museum of Future in Berlin and the Foundation for German-Polish Cooperation, resulting a project celebrating 100 years of Kaluza's 5<sup>th</sup> Dimension in a geographically distributed interactive hybrid exhibition, as presented in our previous paper [1]. The same year started a new master's degree program in 'Electrical engineering - Higher technical facility management', which is designed as a part-time course for students who are already in full-time jobs. The new students had insights into the ongoing project on various occasions. Follow-up projects were dedicated to the uses of compounds of naturally occurring radioactive elements for their colors, and special optical effects in paintings, like polarization and retroreflection. The results were presented in several multimedia based vernissages. In the first group of students several student papers were inspired by these projects and delivered input. Two master's theses in progress are directly linked to the projects. Topics include historical aspects of occupational safety and special polarization based imaging techniques for metrology. For a vernissage at the summer celebration at our new location, a now permanent exhibition in our electrical engineering laboratory was installed, making this working place for the students a friendly and colorful environment and an inspiring place in an otherwise modernistic new building. In the paper, we discuss the surprising motivating effect of art projects on design and choice of topics by students, especially working part-time students. With the paper, we deliver a short explaining manuscript to the otherwise very graphical poster. The poster is supported by multimedia material from the vernissages. So the paper should be read while having the poster at hand. The figure numbering refers to the poster figures.

## 2. NEW MASTER'S PROGRAM AT BBW UNIVERSITY BERLIN

In 2021, a new master's program in electrical engineering was launched at the bbw University. The course lasts 5 semesters part-time. At least 75% of the study time is held online via video conference as a live lectures in the evening hours. The course specializes in "Higher Technical Facility Management" and is aimed at students in the field of infrastructure. The students are mostly engaged in full-time jobs, often 40 hours per week. Most students do not live and work in Berlin, but rather are spread across Germany.

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The course is essentially aimed at the methods of higher electrical engineering. Linear and nonlinear systems theory and analogy methods are particularly important here. The field of optics is implicitly and explicitly represented several times.

Another focus is operational issues at infrastructure providers. In particular, the course creates a connection to the trades and areas of construction without the aim of training as a civil engineer. For further details see the green curriculum.

### 3. STUDY CONDITIONS/ MASTER'S THESIS TOPICS

Many students have already acquired their bachelor's degree at the bbw University as dual students, i.e. they were already employed in industrial companies in the first part of their studies. While the bachelor's degree is paid for by the training companies, the master's degree is usually financed by the students themselves.

Topics for bachelor's theses usually result from ongoing projects in the training company. For legal reasons, it is often not possible to choose topics from employment relationships for the master's thesis. Due to the reduced degree of freedom in terms of working hours, it is difficult for many students to find suitable topics for their master's thesis. Added to this is the fact that due to the limited physical presence at the university, laboratory-related topics also have little chance of success.

Finding technical tasks that can be mastered independently of a full-time technical job turns out to be difficult.

### 4. ARTS AND SCIENCE/MUSEUM OF FUTURE

In our project: "The colors of the radiant discoveries of Maria Skłodowska - Curie and Martin Heinrich Klaproth" in 2023, we took up the topic of naturally occurring radioactive substances and the early history of their use. Among the first discoveries Klaproth made on Uranium was the range of colors its compounds produce in glass and glazes, which became a main use of uranium. Fig. 7 shows the variety of such historical samples. Mainly, the project is dedicated to an artistic implementation of the colors and glow of uranium and radium compounds in non-radioactive paintings by W. Stypa.

Fig. 3 Shows impressions from a vernissage November 2023 with paintings by W. Stypa. In simulated uranium orange and yellow as part of the color palette of the uranium color factory of St. Joachimsthal/ Jáchymov in Bohemia, Czech Republic, and in luminescent paint, as it resembles the use of radium in self-glowing applications [2].

In preparation for further projects, attempts were made with polarization-based artworks designed for interactive exhibitions with audience participation. Figure 4 on the left shows experiments with folded films in cross-polarization arrangements.

For experiments with projecting film material onto paintings, high-speed video was recorded and processed into films with a soundtrack. Fig. 5. Shows still images from the artistic documentary "Jets and Collisions - Waves and Membranes" by C. Hahlweg / W. Stypa. The color range supports the uranium project. The soundtrack made extensive use of convolution experiments, which are used as examples in lessons on signal processing and Fourier optics. A sample video is found at the link <http://dx.doi.org/10.1117/12.3028239.1>; <http://dx.doi.org/10.1117/12.3028239.2>; <http://dx.doi.org/10.1117/12.3028239.3>

The experiments with projections of paintings onto paintings that had already begun in the 2021 project cited above led to experiments with video feedback from paintings onto themselves [1]. Arrangements that are on the verge of self-excitation are particularly interesting. Such arrangements can directly engage the audience in interactive exhibitions simply through the presence of people.

Fig. 6. Shows still images from arrangements with the projector's and the feeding camera's axes being aligned towards paintings by W. Stypa, where the system is almost self-excited. These results also became part of lessons on stability of closed-loop systems.

## 5. MASTER'S THESES INSPIRATION

Coming back to the problem statement 3. If technical topics from the professional activity are out of the question, it is often necessary to find topics that can be handled at home. We also observe that it seems easier for some students to get involved in topics outside of their professional activities. It turned out that involving students in our art and science projects is inspiring for many when it comes to finding topics.

Household objects as shown in figure 7 inspired a master's thesis by C. Fessler on "Naturally occurring radioactive material (NORM) in recent occupational safety". It is an ongoing project, hence no further reference can be given. The exhibition referred to in fig. 3 was accompanied by historical and scientific information material provided by C. Fessler.

The investigation of polarization based imaging techniques has a long tradition at bbw University. An ongoing thesis project is a master's thesis by C. Martini on "Polarimetric Imaging Mobile Phone Application for Large-Area Surface Inspection", which was inspired by the experiments shown in figure 4 left and the investigation of the optical effects in certain paintings by W. Stypa. Fig. 8. shows examples images from the related paper [3].

The completion of a project using original windows from the demolished Palace of the Republic in Berlin is planned for 2025. Some of these windows are physically available to us, see Figure 5 on the right. They are an example of the combination of thermal insulation glazing and stylistic elements in the architecture of the 1970s. Among other things, a thermal model of the building will be created.

The methods for thermal modeling using network-based analogy methods were further developed by J. Laser as part of his master's thesis "Modeling dynamic thermal systems with radiation exchange and distributed parameters using thermal-electrical analogy in construction applications", see the related paper [4].

## 6. SIDE EFFECTS, SUMMARY AND OUTLOOK

In April 2023, the bbw University moved into a new building in Berlin-Adlershof. The electrical engineering department also received a new laboratory. For the inauguration of the new building in the summer of 2023, a large art exhibition was installed in the laboratory and opened with a vernissage, see Figures 1 and 2. With the support of the Museum of Future and the Foundation for German-Polish Cooperation, the exhibition has now entered its second year be taken over. As a result, the laboratory lessons now take place in the art gallery, bringing warmth and color to the otherwise modern and cool interior. With the implementation of further funded projects, we hope that our students, especially online students, will be even more involved. At the same time, we want our students to see academic studies as broadening their horizons, not just as training for a specific job.

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