

A Trip to Arts for Computer Graphics Students

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Abstract

Complex and sophisticated projects, on which information technologists and artists meet and cooperate, often require an understanding of possible problems and solutions seen from both sides. While artists (creators) are usually somewhat familiar with current technologies, e.g. the Computer Graphics (CG) field, programmers are not well educated in the arts and their understanding of artistic needs is thus insufficient. In order to improve the education of CG students towards fine arts, we have created a BSc course on Art and Graphics design and have been running it for seven years. We consider this approach to education at a technologically oriented university as unusual and rare, but highly valuable for CG students. This paper describes the content of the course, summarizes the experience gained, and evaluates its usefulness for CG students in the subsequent MSc study program.

Categories and Subject Descriptors (according to ACM CCS): J.5 [Arts and Humanities]: Fine arts—, K.3.2 [Computers and Education]: Computer and Information Science Education—Computer science education, Curriculum

Motto

*In 1482, Florentine ruler Lorenzo de' Medici commissioned da Vinci to create a silver lyre and bring it as a peace gesture to Ludovico Sforza, who ruled Milan as its regent. His ability to be employed by the Sforza clan as an architecture and military engineering advisor as well as a painter and sculptor spoke to da Vinci's keen intellect and curiosity about a wide variety of subjects. Like many leaders of Renaissance humanism, **da Vinci did not see a divide between science and art.** He viewed the two as intertwined disciplines rather than separate ones. [<http://www.biography.com/people/leonardo-da-vinci-40396>]*

1. Introduction

Throughout history many scientists and artists have worked together. Nowadays, the problems being solved are much more complex than at any historical time, ever. This requires the cooperation of several people that constitute a special team. Mutual cooperation between the members of such a team is always crucial. In this paper we deal with special issues in the field where such collaboration is a must. This is the field of applications where computer graphics play an important role – computer games, movie industry, web design, etc.

The traditional approach in this very field is that artists are acquainted with some basics of computer graphics, e.g. they may acquire special training in the usage of some CG tools like graphical editors, modelers, etc. This solution worked quite satisfactorily in the past. As modern applications often require the usage

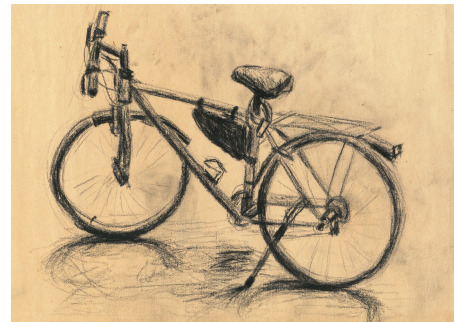


Figure 1: Example of student work – artistic picture of a technical object.

of special tricks with the use of sophisticated hardware this traditional approach suffers from several disadvantages – an artist is not usually an expert in software and/or hardware details or in mathematics that may also play an important role in the smooth running and high-quality visual outputs of particular applications. Creative artists need to cooperate with CG experts, to explain their visions and dreams, to accept possible technological limitations or to push information technologists to overcome them. This symbiosis between technology and art requires intense communication. As the creative processes used in art differ significantly from processes used in the field of technology in general (and particularly in CG) it is necessary to create a sort of bridge that may help both sides to reach mutual understanding.

At CTU (Czech Technical University in Prague, the largest technological university in the Czech Republic), such a bridge has taken form in the *Art and Graphics design* course in which CG students gain a basic idea about the processes that are used during the creative work performed by artists. These acquired skills can be later efficiently applied by graduates when they are employed in companies that use computer graphics with some flavor of art.

We use the term "CG student" for technological CG students in both BSc and MSc programs at CTU. While the BSc program (3 years) provides basic knowledge of programming (Python, JavaScript, C/C++, OpenGL), multimedia processing, game development, and web technologies, the MSc program (2 years) concentrates on advanced techniques like real-time rendering, visualization, computational geometry, and visual computing. The majority of our students attend both "CG programs" in succession thus acquiring a complex CG education in 5 years.

Our CG students are primarily taught how to create graphics software. Up to now there has been no study program that links Technology and Art. The introduction of our course is an attempt to solve this problem, at least to some extent. As the presented course is included in a BSc program, students are quickly acquainted with artistic ways of creation in order to apply this knowledge to their further education in various CG courses included within the MSc program. The course is scheduled for 14 weeks, consisting of 2 hours of lectures and 2 hours of seminars (where students mostly draw) per week, and providing 5 ECTS credits to the students.

This paper introduces similar approaches at selected universities and concentrates on education specific to CG students (Section 2). The curriculum of the Art and Graphics design course presented is described in Section 3 along with a number of examples of student work. Student feedback is presented in Section 4 and the overall contribution of the course is summarized in Section 5.

2. Related work

The idea of combining art and CG is not a new one. The use of CG in art is in general linked with many problems and efforts [Dav94]. Artists had to become accustomed to a new style of working together with the mastering of formerly unknown CG technologies. The problem is that every year new tools are emerging on the market; thus, artists should learn new technologies – in many cases even in the tiniest details. Such a situation may become even worse as the hardware and software platforms get more and more sophisticated, requiring specific know-how in the field of CG. This fact may be a motivation for closer cooperation between artists and CG experts.

In university curricula around the world, several attempts have been made to merge the worlds of CG and art, e.g. in [Oli99], a study program is described in which CG students are educated in disciplines like aesthetics, human computer interaction, multimedia techniques and other issues. Most of these courses are linked with CG - especially in the area of computer games - where art plays an important role. CG graduates who are later employed in the computer gaming industry are then aware of other issues than only the CG ones.

The importance of cooperation between CG experts and

artists/designers was presented in [BA06]. Here students should create an interactive 3D virtual environment, where each group of participating students was comprised of one CG and one graphical design student each. Students could mutually influence each other during their work. Moreover, at the end of the project students found that other "types of designers" may also be useful - like a sound designer or a specialist in narrative.

In [Ebe00] a traditional approach is described where students of art become acquainted with CG. The main idea is to offer art students a new set of tools for their creative work. These CG tools can be used in a wide variety of art disciplines; including photographs, video, 3D modeling, etc. For advanced students there is the possibility to penetrate into the basics of programming, which allows them to use more flexible tools – like the usage of scripts, etc.

A good example of a study program where CG and art meet is the program at Ashland University [<http://www.ashland.edu/cas/majors/computer-arts-and-graphic-programming>]. The motto for this study program is: *If you are a technologically literate artist, it may be for you*. Here the artists become acquainted with a set of techniques used in computer graphics, multimedia, etc. This approach offers them the possibility to transform their (artistic) ideas into the world of technology.

Another study program that supports a combination of CG and art is described in [OC00]. This BSc. study program integrates CG disciplines and non-CG theoretical disciplines like aesthetics, psychology, etc. Students who enrolled in this program came from both a CG and non-CG environment. Their ability to be successful in this particular study was tested through a complex entrance test. The education was primarily targeted to the needs of the industry which was supported by a special block in the curriculum where a sort of internship in industry (e.g. computer game companies) was performed. That is why the students were taught various CG tools including tools for multimedia and movie creation. Students were thus aware of the existence of various points of view (CG and non-CG) when solving special problems in practice.

An example of a study program connecting Art and Technology is in [CMA10]. The program is oriented to education in the field of digital animation where a combination of Art and Technology courses creates a new quality of education in the field of CG.

An interesting example is study program at Kingston University [<http://www.kingston.ac.uk/undergraduate-course/computer-graphics-technology/>] where students are taught drawing techniques with the aim of expressing their ideas (when communicating with artists, designers, etc.) by means of drawings. This approach teaches students to formulate their ideas in another form than they were previously accustomed. Through communication with artists they may acquire a new view of problems (and their solutions) that should be solved in a CG environment.

Also in [CD02] there is a description of a course given at the University of Bristol where CG students should prove their ability to draw. Perceptual issues are stressed in this course, as they should later be used in student practical work when generating synthesized images where luminance and reflections play an important role. Through the use of drawings the students acquire a feeling for light distribution in a 3D space and in such a way that they can

influence the process of synthesized image generation more efficiently.

The course [CD02] was a sort of inspiration for our course where drawing plays a role (even though the purpose of drawing is different in our case). An efficient drawing of 3D scenes requires a certain amount of training that may be quite a new experience for many CG students. They know that the drawing of a 3D scene is a transformation from 3D into 2D. Such a problem can be formalized in a certain way. A good overview of such an approach is in [Dur02] where the transformation process is divided in several steps that when combined together may present a sort of formal framework that may be used to support picture creation in the area of CG. One of the steps is the concept of a depiction that may be described in terms of two systems: the drawing system and the denotation system [Wil97]:

- *The drawing systems* are systems such as perspective, oblique projection and orthogonal projection that map spatial relations in the scene into corresponding relations in the picture.
- *The denotation systems* map (...) scene primitives (...) into corresponding picture primitives, such as regions, lines, or points. In this way, depiction involves two kinds of decisions: which primitives to use (denotation), and where to put them (drawing). It is obvious that this problem can be handled from the computer graphics side (proper usage of transformation matrices, etc.) or from the art point of view (usage of human feelings of how to place certain objects into pictures).

In the framework of cooperation between artists and CG people the latter approach plays a dominant role. This is why it is necessary to develop an educational system that supports this approach.

To summarize this overview of university curricula and approaches we can say that the problem of synergy between CG and art, in terms of education, has been trying to be resolved for quite a long time. The prevailing approach was to teach artists the basics of computer graphics, while CG students did not have many chances to get "hands on" experience (learning by doing) with art. That is why our suggested approach is based on CG students being introduced to the field of art.

3. Art Education for Computer Graphics students at CTU

Our innovative approach used in the *Art and Graphics design* course is based on the concept of **immersion into art**. This concept consists of two basic components:

- "Forcing" CG students to feel and think like artists during the creation of a piece of art.
- Giving them a basic idea regarding the concept of art in general.

The first step towards the realization of this concept was seeking a teacher with experience in both general art and digital art, in particular. Such a combination had to guarantee that some mutual understanding between the teacher and CG students may have been reached. The person with the required properties is Lucie Svobodova (the first coauthor of this paper). She has an impressive record of activities in new media art, which includes exhibitions in respectable institutions and galleries including the National Gallery in Prague. Her artwork is featured in important public collections in

the Czech Republic. Additionally, her record in the field of teaching is impressive - it includes teaching in the most respectable art schools in the Czech Republic; such as the Faculty of Fine Arts at BUT in Brno, or the Academy of Arts, Architecture and Design in Prague.

The second component informs students on the reasons and motivations for some drawing techniques taught within the first component, along with rules that drive the creative process. In such a way, a window to the world of art is opened for CG students. This experience allows them to communicate better with artists in future (as they get some idea about the way the artists think).

A key principle for bringing the concept to life was defined as: the creative processes are of universal nature regardless of whether the work of art is created using traditional means (pencil, brush, chisel, etc.) or by some tools based on CG technologies. In our educational process the effort has been concentrated on the area of drawing, using charcoal as a medium. The usage of this traditional medium, applied for centuries in art education, represents another pillar in our bridge between technology and art.

3.1. Part A – Creative process investigation via drawing

The process of painting may be characterized as the transformation of 3D information in 2D. This process deals with several issues; such as perception, cognition, and the personal interpretation of 3D information, when being transformed into 2D (as well as other issues). In order to penetrate as deeply as possible into this particular process it is necessary to start with simple 3D objects where these basic issues are demonstrated. The aim of this scheme is to show the aspects of the transformation process in all its complexity, beginning with simple transformation rules and ending with relatively complex rules.



Figure 2: Exercise on angular objects.

Mastering the work with these transformation rules requires personal experience with the application of these rules. This happens during lectures and seminars where practical exercises are being performed. An accompanying activity in which the concept of art in general is presented are visits to galleries where the techniques used by skilled painters are demonstrated. Such a demonstration creates a context in which students may better understand the techniques (rules applications) used in their own creative process.

The basic idea is to train the human eye. The trained eye perceives a 3D scene using a transformation from a 3D scene into a 2D picture that is optimized in a certain way. This means that the eye sees details, understands relations between objects in the scene, etc. Another aspect of eye training is the better coordination of the perception process and fine motorics of the human hand. Such synergy between eye and hand allows the student to draw pictures – the quality of which depends on the talent of the student. Nevertheless, the quality of the picture is not the main goal of the training within the framework of the course.

Such training has a certain structure. It is obvious that it is not possible to start with complex 3D scenes. The basic principles should be practiced using simple objects where features like perspective, illumination of parts of the object, etc. will be perceived and finally drawn in the picture created. These issues are explained from the point of visual thinking which creates a base for better understanding of the concept explained.

The first scene that is to be drawn is made up of objects like a parallelepiped, cube, pyramid, etc. (Figure 2). When drawing these objects, students become acquainted with the importance of the selection of viewpoint, illumination, perception of depth, etc. These 3D features should be expressed in a 2D picture by means of techniques like thickness of lines, proper density of shading, etc. Basic drawing techniques are also trained; such as the importance of drawing a line by a single hand movement (not drawing a line as a sort of polyline).

The next step is drawing nonplanar objects – namely spheres, cones, etc. (Figure 3). Here the effects of shading, reflection and their representation in the 2D picture are also exercised in order to achieve the impression of a 3D space. Moreover, the students have to depict various physical materials and their properties like glass, smooth surfaces, patterns on clothes, fur, etc. (Figure 4).



Figure 3: Exercise on curved shapes.

The drawing of basic objects allowed the students to get an idea about the properties of light, as well as to get a feeling for the structure of a 3D scene. The next step is a composition of the scene. In corresponding lectures, the students acquire information about the basic concept of the organization of the layout of objects in the scene with the intention of obtaining eye pleasing effects for the

viewer. The main concept is the rule of the golden ratio. This rule creates an interesting link between mathematics (also in some form with computer science and computer graphics in particular) and art. Such an approach helps to stimulate students in a multidisciplinary way of thinking, including a visual one.

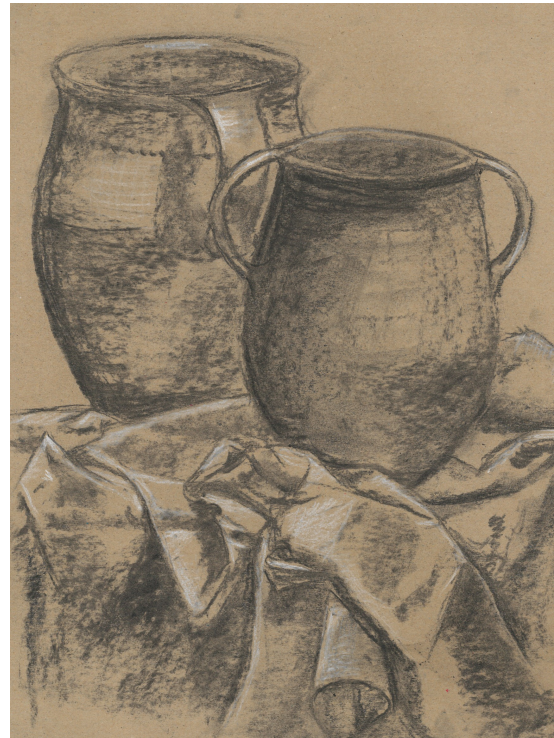


Figure 4: Exercise on more complicated surfaces.

A practical application of the knowledge about the scene composition is performed through tasks in which students are to design and draw a simple scene containing either planar objects (e.g. table and chairs) or a scene composed of several pieces of fruit, etc. Students are informed of the rules that are applied regarding the layout of furniture in a room, the layout of objects on the table, the design of a garden, etc. Such rules help in achieving a harmony of the space that has to be drawn.

The highlight of the creative process performed by students is figural drawing (Figure 5) – students should draw human faces of various people and finally a human body – the key to understanding general aesthetic rules. As figural drawing represents the most difficult type of drawing that students are to draw the students can realize the drawing process in its full complexity.

For the sake of simplicity all drawings are made in black and white. Recycled, yellowed or brownish paper is intentionally used. This allows students to concentrate on basic drawing techniques and not to be disturbed by additional issues like colors, combination of colors, colors in shading, colors in textures, etc. Nevertheless, information regarding the importance of colors is presented in lectures. Students acquire information about the properties of colors from the point of perception and also about the psychology of colors.

3.2. Part B – Accompanying benefits of the drawing techniques learned

The learning of basic drawing techniques and accompanying principles of creative processes are the main occupation for students in the first half of the semester. The second half of the semester is dedicated to another way of fulfilling the concept of the immersion into art. There are two parts to this effort:

- Showing students how *respected painters used the techniques learned* (in such a way students can see the application of these techniques with much better results than they could achieve – thus, they could better understand why these techniques were developed and used).
- Showing students applications of these drawing techniques in an environment they are familiar with – some *applications in the CG industry* (in such a way they will be convinced that the approach taught may be of significant importance in the CG industry).



Figure 5: Exercise on figural drawing.

The first point is covered by a guided tour of the National Gallery in Prague, where pictures of various styles drawn in various periods of time are on display. The lecturer - who is the guide - performs a careful selection of several pictures that demonstrate the usefulness of the drawing techniques taught. Having personal experience with the drawing techniques students can better understand the messages communicated by the pictures shown. For many students this is the first professionally guided tour of an art gallery. In combination with previous drawing experience they are able to create a personal (positive) relation to art, and to understand the nature of creative processes in art.

Another activity in the field of immersion into art is represented by a lecture in which students become acquainted with basic historical styles. The idea is to show the development of historical styles beginning from Romanesque and ending with modern styles. The

styles are demonstrated in an entertaining form: video sequences from movies where these styles appear (along with other artifacts related to the corresponding period of time – like clothes, paintings, statues, buildings, etc.). Such specific lectures help students better understand the process of development of art and highlight the key historical and cultural moments connected to art.

The usefulness of the knowledge acquired regarding the creative processes should later be demonstrated in examples that students are familiar with from their previous experience in the field of CG. Before students enter the course they (mostly) know about some rules recommended for the usage of certain fonts or color combinations in web design. They take them as sort of axioms without any knowledge of their background. The course gives precisely this background (students now know WHY some rules were defined). From this moment on they are able to think more in detail about the use of these rules – and even more: they may consider other possibilities of the usage of the rule in accordance with the new knowledge, dealing with the creative processes, acquired. This new approach can be considered as a side effect of our described course.

Providing information about the nature of creative processes, students can better understand the individual phases of artistic ways of thinking and doing. It allows them to employ various CG technologies or some techniques more efficiently, e.g. to employ animation preview of the low quality in the interactive phase of the picture (design) creation, when high quality rendering should be employed in the final stage where more detailed rules may be used.

This course is very different from other courses CG students should go through – it provides them with the possibility to think and act in a different way than they are accustomed to. Such an approach can train students to see problems from a different angle and can thus improve the creativity and problem solving abilities of students in their own particular field.



Figure 6: Free drawing. See the fascination created by a CG student using shades and shadow.

In terms of assessing student work, we developed a strategy that reflects two aspects:

- 50% of the assessment covers the student's approach to their drawings - mastering the techniques presented, application of knowledge of basic principles of art work, reflection of teacher's comments, etc.

- 50% of the assessment is derived from the quality of the semester project. This project is in the area of graphic design, where knowledge acquired during the lectures should be applied. This knowledge covers composition rules, color theory, typography, and the basics of photography. The assessment shows how the rules mentioned above were applied.

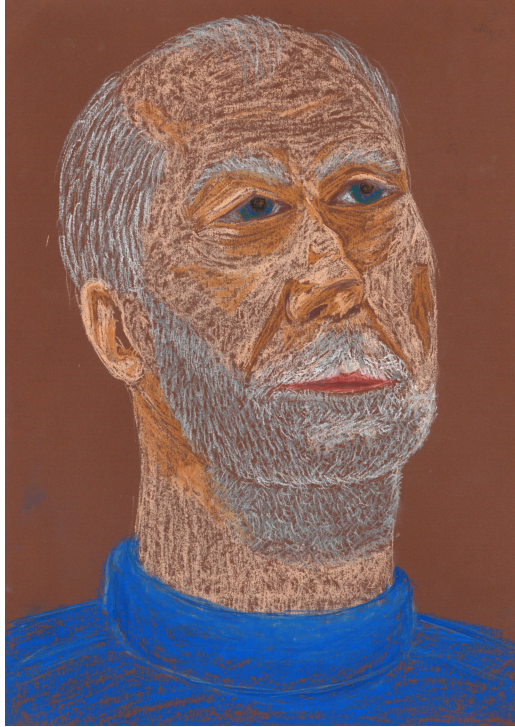


Figure 7: Colors are offered to advanced students only.

4. Evaluation of benefits brought by the concept of the immersion into art

Every new method or concept should be evaluated with the aim of getting feedback on how this method was accepted by a target group. Our goal was to introduce a new concept by means of which the CG students should get a sort of introduction into art and into the methods that are widely used in the artistic creative processes. It was necessary to define some metrics that could give a measure of how the new methods delivered in the form of the course were accepted by students. One type of information has been acquired from students during their interaction with the teacher during lectures and seminars. The second type was a questionnaire that is filled in by students at the end of each semester. Filling in this questionnaire is not an obligation – the return ratio differs for various courses – but in the case of the course discussed the return ratio was about 32%, fairly above average at the faculty which is less than 25%. The questionnaire contains several questions which can give a relatively good image about the course acceptance. The answers to these questions result in the final "magic" number that expresses the overall quality of the course in accordance with certain metrics that cover parameters like quality of the teacher's oral presentation, quality of materials that accompany the course, quality

of the exam - whether the exam was demanding but fair, etc. The questionnaire is a standard tool used by university management to follow the quality of teaching.

Considering the "magic" number we see that during the last seven years (when the course was being conducted) its value varies between 1.1 and 1.25 (the scale is from 1.0 to 4.0). This means that the course is considered as one of the very best courses ever. The answers to open questions in the questionnaire are positive as well – students usually appreciate that they were able to come into contact with "real art" through a professional artist. Up to this point, CG students were accustomed to working with virtual objects that "live" inside computers only. This fact influenced their perception of the surrounding real world. When working with real objects like charcoal, paper, etc. they find out that the style of work substantially differs from their own previous experience. In such a way they can consider another approach to problem solving that supports the development of their creativity than they could in their former (CG) environment. Other positive feedback can be characterized by the appreciation of gallery visits and movie presentations, where they came across a basic introduction into the world of art. In many cases the shots from movies in which architecture and related art disciplines were shown inspired students to watch similar kinds of movies later on.

There are also other points that speak in favor of the course. There is always certain number of students who continue to attend the course even though they cannot get any credits for their repeated effort. There have been cases in which some attended the course up until the end of their studies. These students can have special consultations with the teacher as they try to continue improving their creativity – they use colors or some other special materials (Figure 7). Under the qualified guidance they gradually improve their drawing skills, and in such a way penetrate deeper into the world of art.

Within the curriculum there is a set of courses where students should master some of the technologies in the field of multimedia. It is interesting that students are aware of the fact that with the knowledge of the basics of creative processes they can better (more efficiently) use the technologies available. This can be proven by the fact that almost all of the students enrolled in the *Multimedia Applications* course took the *Art and Graphics design* course in advance. The same phenomena can be observed in other CG courses like *Modelling and Animation* or *Realistic Image Synthesis* (Figure 8).

The positive influence of the course was observed through the higher quality of student presentations given in other courses, as well as in conference posters; knowledge of some of the rules from the world of art played an important role in this improvement.

Part of the education is an event – a ceremony opening an exhibition of the best work done by students. The winners are awarded a prize. The pictures created by students are exhibited throughout the semester, until the end of the next semester when the pictures are replaced by new ones. As the pictures are publicly available new students are aware of the existence of this course and their interest in this course is maintained at very good level. Throughout the previous seven years, an impressive number of 550 students have attended and (in most cases) successfully finished the course.

Perhaps the most convincing fact regarding the usefulness of the course is shown in the *Intermedia design and technology* course in which an emphasis is placed on larger student projects. These projects are organized as teamwork where teams consist of CG students and students of art (from the School of Art from another university). These unique collaborative projects are highly appreciated both by students and a public audience. As examples we can mention some light shows and performances that took place on the occasion of various cultural events (like interactive art in a gallery, light sculptures in public space, etc.). Graduates from the CG study program therefore have a very good position in the labor market where specialized companies are looking for graduates with experience in both CG and (to some extent) art.

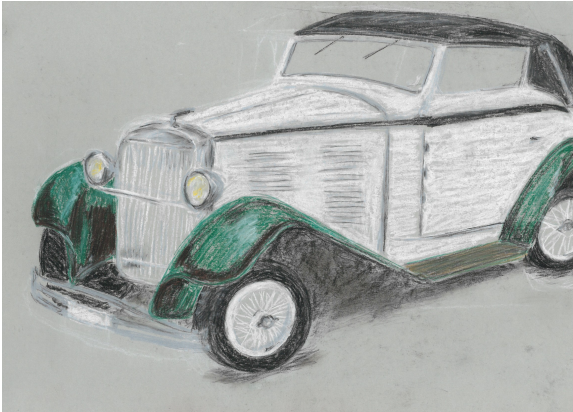


Figure 8: A student started with a drawing of old car in this course (top) and ended up with a render of illuminated 3D model in subsequent course in MSc program (bottom).

5. Conclusions

The main value of the course described is the innovative approach where CG students are systematically taught about creative processes in the field of art. In such a way they will be able to reach better communication with artists when working on joint projects. Last but not least the basic understanding of the concept of visual thinking helps students to understand some issues in following courses like Visualization, etc.

The approach described in this paper is complementary to traditional approaches in which artists are taught how to use CG tools.

Such a traditional approach was appropriate in situations where a single artist worked on his/her project with the help of some CG tools. Nowadays, when the complexity of art project is increasing, the creation of teams in which artists and CG experts cooperate is inevitable.

As the technological development in the field of CG is very fast, the approach in which artists should absorb new information from CG puts immense requirements on artists, as they should become oriented in a field they are not very familiar with. This fact may sharply emerge in situations where cutting edge CG technology should be used. It is then that our well prepared graduates will be able to use technology to its full extent, thus reach maximum performance in synergy with artistic requirements. There has recently been quite a few art projects in which our CG students or graduates took part.

There is also another benefit of the course – CG students are able to design and develop new graphic tools for artists. As they can better understand the requirements of artists these new tools are of very high quality and are tuned to specific artistic needs. Some good examples from the field of movies, animation, and image processing are described in [SBCv*11], [LFB*13], and [JFA*15].

We consider the course successful. There has been very positive feedback from students. There has also been a positive reaction from students and teachers in follow-up courses in the field of CG. There have been many projects in which CG and art have come together. And it was here that the better cooperation between artists and CG students was verified. In brief, all of the feedback was gathered in an informal way (which, in our opinion, does not diminish the overall positive impression that the course has aroused). It might be nice to have a more formal assessment of the course's success; this would require defining appropriate metrics for assessment and performance of a large scale experiment with control groups, etc. That could be a challenge for future research in the field.

The main advantage of the course is its compactness, in which students acquire all of the necessary information about creative processes in art. Such an intensive, one semester course is very time efficient compared to extensive study programs in which the topic (artistic creation) is distributed throughout several courses. The current form of the course is a result of the effort which lasted for several years where a good balance among the individual components of the course was finally achieved. We are going to run the course in the future in its current, finely-tuned shape.

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Figure 9: CG students during their creative work.



Figure 10: Example of student work created during seminar captured in Figure 9.

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