

Article

Difference between Learning Basic Form Generation and Automotive Exterior Design

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Abstract: This study explores the correlation between learning about basic form factors and learning automotive exterior design (AED) for the first time. To help beginner AED students learn smoothly, we developed modular courses and proposed to teach basic form generation. Six modular assignments were developed for the courses on Form Theory and Transportation Design, and 22 and 20 students, respectively, completed all the assignments of each course. All students were guided to become familiar with the five form factors: proportion, contour, volume, surface, and detail. According to the student self-assessments and responses for the Form Theory course, students gained a statistically equivalent learning experience of form factors from the four assignments; however, they gained significantly different levels of understanding and confidence. There was also a significant difference in understanding form factors during AED clay modeling. Further, students considered that the last two assignments in the Form Theory course had a significantly stronger relationship with learning AED than the first two assignments did. These findings are conducive to ensuring improvements in the modular courses to help future students begin learning AED.

Keywords: form generation; modular courses; automotive design; design education; industrial design

1. Introduction

A good product attracts consumers and communicates with them. In other words, a product's physical form is undoubtedly a determinant of its success in the market [1]. In the field of industrial design practice, the creative generation of product shape is considered both an element of innovation strategy and an effective tool to address competition [2]. The visual aesthetics of a product's shape enable companies to gain higher profits by making the product impressive, thus decreasing the level of its price sensitivity [3]. To diversify innovative solutions, it is better for design students to have a good command of product form, and innovative design courses are thus becoming more vital, with an increasing number of institutions are looking to provide such courses [4,5]. On the other hand, the design principle of 'form follows function' proposes that a product's form generation should primarily relate to its intended function, use, and purpose, and this principle continues to be advocated by many design practitioners and is deeply rooted in basic design education [6,7]. Thus, rational analysis of product function is important, and well-planned design research can help increase the chances of success of a product design [8]. Contrary to this, however, John Maeda has said that the easiest way to simplify a system is to remove functionality [9]. The importance of improving the sensitive ability of integrating form generation, a key factor of innovative design, has also been discussed [2].

During the product design process, designers always attempt to create value for consumers by enhancing the visual aesthetics of products to make them more 'special' [3]. In the design communication framework, cognitive response to a product's form comprises aesthetic impression, semantic interpretation, and symbolic association [10]. This study is related to the education of aesthetic impression, which is defined as the sensation of attractiveness (or unattractiveness), and is related to the application of a visceral level of design [11] and intrinsic attractiveness [12]. When product shape is perceived as unique and prestigious, consumers tend to decrease their sensitivity to price and become willing to pay higher prices [3]. In automobiles, which are high-priced consumer durables [13], automotive exterior design (AED) always emphasizes the vehicle's attractive visual impression, more so than the designs of other consumer durables. Thus, this study investigates the relationship between learning AED professionally and the basic learning of form generation in design schools. Logically, learning AED is more advanced and difficult for students of industrial design. There is no academic institute in our country that specializes in AED. Collaborative teaching with professionals from a local industry is our means of developing higher industry–university cooperation. Thus, we interviewed three automotive design experts who divided the hierarchy of car styling (i.e., AED) into five two-dimensional (2D) and three-dimensional (3D) factors: proportion, contour, volume, surface, and detail. Each factor is based on the former factor, and they are all integrated with one another to form an interrelated whole.

In this article, we begin by presenting a theoretical framework related to basic form generation and the high demand for AED. Then, we describe how we developed the new modular training—as well as its contents—based on AED experts' suggestions, so that beginner AED students could gain knowledge in this area of expertise smoothly. We developed two courses—Form Theory and Transportation Design—that included a total of six assignments for industrial design students. The correlation among all modular assignments is explored by statistically analyzing student self-assessment data. We also discuss guidelines and suggestions for future beginner AED students, and present the limitations of the conducted research. We conclude with further reflections on the implications for modular courses. The following is the focus of this study: What type of design courses and assignments are suitable for design students to improve their skill enough to address the high demand for AED?

2. Theoretical Framework

Products are often functional devices that are used to perform certain tasks. Their function and operation can be conveyed or indicated by product form [12]. Under the influence of the concept of 'form follows function', product design students are systematically trained to rationally express the appropriate product form according to product function. The physical product may be characterized by its various attributes, including geometry, dimensions, texture, material, color, and detailing [10]. In the field of automotive design, five factors of car styling are constructed hierarchically. Among these are the spatial factors of car styling, proportion, contour, and volume that designers use to construct automotive interior space. The surface of automobiles is often used to express dynamics and light, which are speed or time factors. In the evolution of the automobile, the feature expressing its dynamic attribute the most is its streamlined surface. Streamlined surfaces were first used as part of AED, but later influenced product design on a large scale [14]. Regarding the details, there are obvious differences between the design of general consumer products and automobiles. In the following, the characteristics of basic form generation and high demand for AED are clarified.

2.1. Basic Training of Form Generation

Gestalt psychology is an important theory for teaching about product form and car styling. Gestalt psychologists propose that people sense external shapes as a whole rather than as a sum of parts. Visual form can be constructed and designed using Gestalt principles of grouping [15,16]. When considering the design of product shape, designers usually adopt images of other objects based on sensible connections with product characteristics [7]. There are several approaches to quantifying

design quality in product design [17]. Professor Rowena Kostellow had a significant influence on basic design education, especially in the industrial design program. Her famous teachings and research focused on the basic elements of design. She insisted that the designer's primary role was that of a form giver, and she believed that both thoughtful manipulation and beauty of form are central to a product designer's role [18]. To have a good command of product form, it is necessary for students to apply these logical methods of exploring and trying to unify multiplicity. Therefore, systematic training projects about form generation are often arranged for students to improve their basic ability to explore a morphological solution. Then, students can be led to a systematic sequence of visual explorations by which they can further develop their comprehension and recognition of basic form generation [19].

2.2. High Demand for AED

All new products should be considered in terms of aesthetics [2]. Automobiles have their own functions and needs by which designers can optimize the aesthetics of their exterior forms. Meanwhile, every object can be traced to its paradigms [20]. For example, the original engine-driven car naturally adopted the paradigm of the horse-drawn carriage [21]. That is, the original car was not much different from the four-wheeled carriage in appearance. Today's automobiles, however, are extremely complex, and the scale of the automotive industry is very different from that in the past. Good design provides such an industry a basis for ensuring market segmentation and for building a larger line from the same investment [2]. Undoubtedly, AED today has a higher demand and more criteria than the design of other consumer durables. AED designers also can be paid better wages due to their higher level of expertise. There is the positive correlation between wage increase and education, which holds true across all industries [22–25]. In other words, college learning positively influences future wages. Since further learning in higher education is possible for students, an increase in wages is expected [26]. That is why students majoring in product design need an opportunity to study AED.

The early classic archetype of the automobile had streamlined surfaces. The most famous example was the Volkswagen Beetle, launched in in 1937. Its sleek and smooth arc form reduced wind resistance to increase its speed, and it thus became representative of car styling [14]. Shaping a form with a sense of speed is still an important part of AED training. However, before dealing with other form factors, beginner AED students must consider proportion and spatial relations, because every type of car has its own proportions [27]. Then, they must deal with the more complex factors step by step, from contour and volume to surface and detail.

3. Modular Assignments

We are a comprehensive university offering a broad choice of courses. Most of our students are from general high schools and not from vocational high schools. In the Department of Industrial Design, the ratio of male to female is about equal. For developing an innovative course on form generation that explores the gap between learning basic form generation and automotive design, six modular assignments were chosen or designed to be administered in the second semester of the second year (four assignments in the course on Form Theory) and the first semester of the third year (two assignments in the course on Transportation Design) in our department. All assignments were designed to correspond with the five factors of form generation (see Figure 1). Assignments 1 and 2 were designed for students to practice dealing with basic form factors, including proportion, contour, and volume, while Assignments 3 and 4 dealt with the basic form factors except for 'detail'. The two assignments about AED were designed to ensure comprehensive training of all form factors. In the following, the six course assignments and examples are introduced.

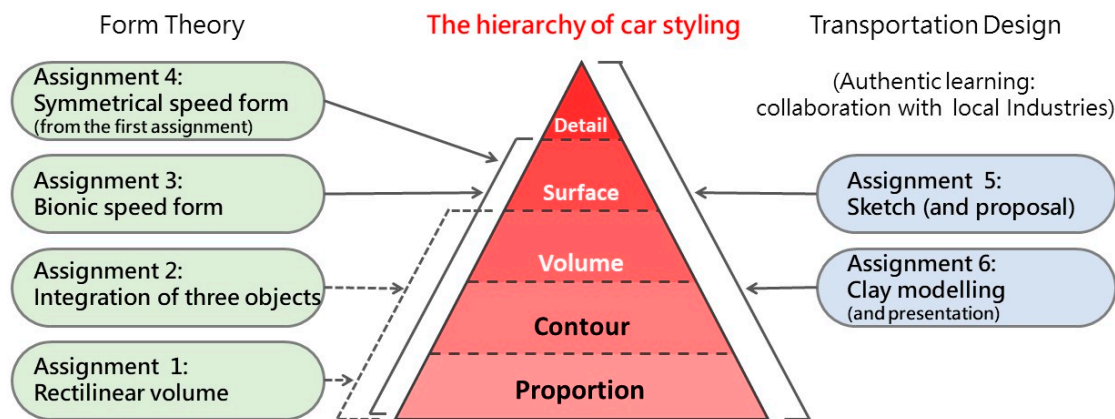


Figure 1. Ideal context of the modular courses.

3.1. Assignment 1: Rectilinear Volume

Rectilinear volume, Professor Kostellow’s first assignment, was the cornerstone of basic training projects. Students were required to use only three rectilinear blocks to express a sophisticated and beautiful outcome (see Figure 2). According to Kostellow, ‘You really have to make these beautiful. That sounds pretentious. How can you make three blocks beautiful?’ [18]. Students were encouraged to make three blocks that were as different in shape and volume as possible (e.g., thin rectangular sheet and long cuboid). By performing this form exercise, students gained expertise in establishing relationships between basic elements by choosing the dominant, subdominant, and subordinate parts. They were also asked to be aware of proportions within an element (including length to width to thickness), proportions among elements (e.g., long cuboid vs. thin sheet), and the overall contour influenced by positioning the axes of the blocks. Therefore, in the first assignment, students were guided through these steps to adjust all the proportions, refine the contour of the façade, and pursue the difference in the volume (see Figure 3).

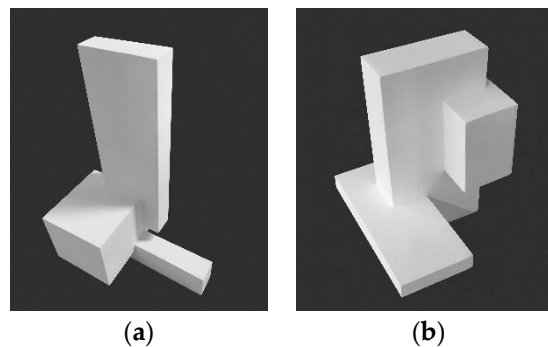


Figure 2. Works of rectilinear volume: (a) the first and (b) the second representatives.

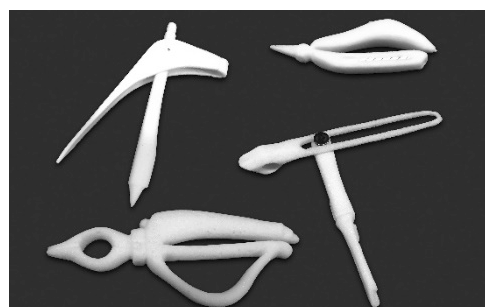


Figure 3. Integration works of three objects.

3.2. Assignment 2: Integration of Three Objects

The second assignment deliberately forced the students to reorganize and deal with the integration of three objects (tools). The design idea of the assignment was based on Gestalt psychology, which has a very close relationship with artistic expression [15]. The concept of ‘Gestalt’ has been applied to art and has deeply influenced design practice [16,28]. Gestalt laws of grouping deal with the sensory modalities of vision, sound, touch, and so forth. The visual modality is dominant, and the most widely used principle that utilizes the law of proximity, similarity, closure, symmetry, common fate, and so on [29]. For applying the Gestalt principles of grouping, students were asked to randomly select three objects from six tools they were familiar with, including a mechanical pencil, a compass, calipers, a utility knife, needle nose pliers, and a screwdriver. Next, they were encouraged to think about how people operate the three tools, and ways to integrate them together using Gestalt principles of grouping. They were also asked to choose one dominant tool and adjust the proportions, contour, and volume to complete the work (see Figure 3).

3.3. Assignment 3: Bionic Speed Form

The purpose of this assignment was to guide students to construct speed forms. First, each student selected one creature whose image he or she wanted to express. All students anatomized the structure into three parts as the dominant, subdominant, and subordinate part, using the theory of the archetype or paradigm. Then, every student continued to adjust the proportion, contour, and surface of the rough archetype. Finally, they completed a simplified bionic speed form (see Figure 4) by optimizing the dominant part, modulating the subdominant part, and controlling the subordinate part. During the training period, students were led to think about how to express the simplified archetype of the function (moving with high speed). Therefore, the main goal of the third assignment was to learn how to express the visual archetype of function, as well as how to control the contour and surface.

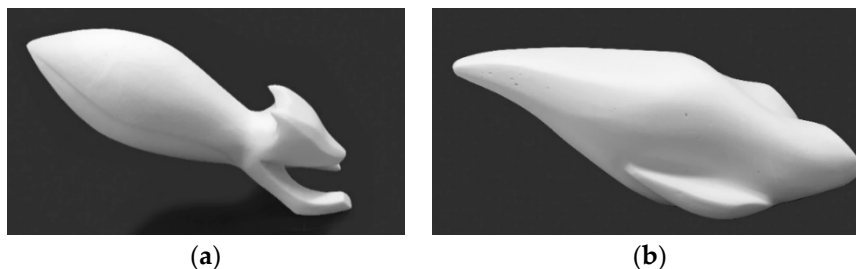


Figure 4. Works of bionic speed form: (a) the first and (b) the second representatives.

3.4. Assignment 4: Symmetrical Speed Form (from Assignment 1)

The final assignment of the Form Theory course extended the results from Assignment 1 to move towards advanced training. Because the visual concepts of many objects, especially automobiles, are characterized by structural symmetries [15], students were led to select one side of their first work as a mirror plane for obtaining a symmetrical structure. Then, they continued to modify the contour and volume with appropriate rounded corners and curved surfaces. Finally, every student created a new shape with aerodynamic characteristics (see Figure 5). During the training period, they experienced morphological variability under a specific framework.

3.5. Assignment 5: Automotive Exterior Sketching (and Proposal)

In the course on Transportation Design, we emphasized authentic learning for students. Collaborative teaching with professionals from a local industry (HAITEC) took place during training in regards to both automotive exterior sketches and clay modeling. Four automotive exterior designers assisted professors in training students, to familiarize them with sketching techniques and concept proposals over nine weeks (see Figure 6). Designers and the professor used internal competition to

simulate the actual environment of working in the industry. Under the rule that all students had two votes, each student chose two proposals from a total of 20 that he or she most favored. Finally, the five concept designs with the most votes were selected. The five students whose proposals were selected were assigned to play the role of chief designers and began recruiting members to organize their own teams. Under the condition that each chief designer led three members, the teams continued to adjust and optimize the proportion, contour, volume, surface, and detail of the original design concept, and then completed the concept proposal, despite inner competition.

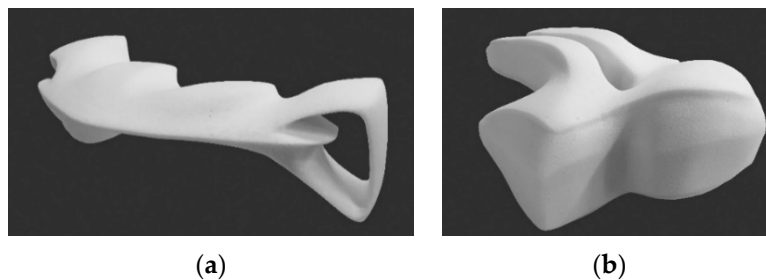


Figure 5. Works of symmetrical speed form: (a) the first and (b) the second representatives.

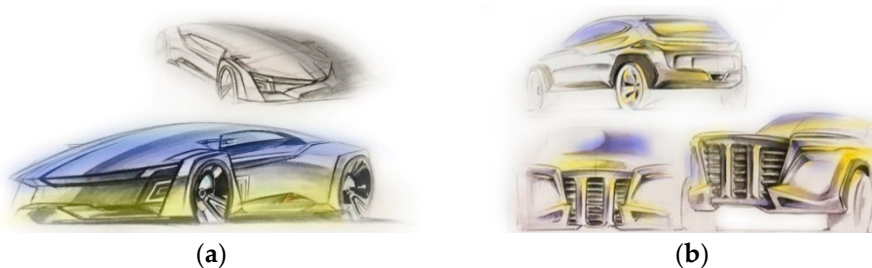


Figure 6. Students' automotive exterior sketches: (a) the first and (b) the second representatives.

3.6. Assignment 6: Clay Modeling (and Presentation)

After the proposal, internal competition, and creation of five teams under their selected chief designers, the students arrived at the next stage, 'clay modeling', followed by a final presentation. During the final assignment, three experienced clay modelers assisted in training the five teams to familiarize them with basic clay modeling techniques. As the students were beginners of AED, a small-scale model was suggested and assigned to avoid a heavy workload. Finally, each team completed a 1/8-scale clay model over nine weeks (see Figure 7).

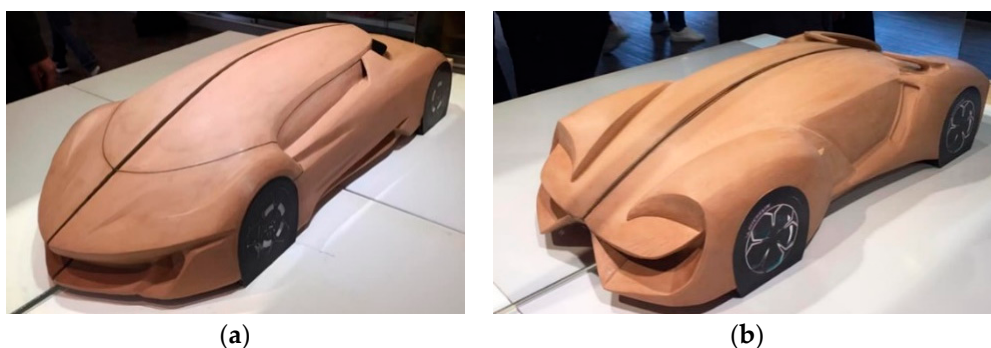


Figure 7. Clay models: (a) by Team A; (b) by Team B.

4. Student Self-Assessment

In the first half of 2018, 28 students were enrolled in the Form Theory course at the beginning of the semester. However, only 22 students completed all four assignments (see Figure 8). Each assignment

period was about five weeks. Students were guided to complete the four assignments to enhance their skills and explore the attributes of basic form generation. For the course on Transportation Design in the second half of 2018, 20 students completed the AED project. Among them, 16 students also passed the Form Theory course.

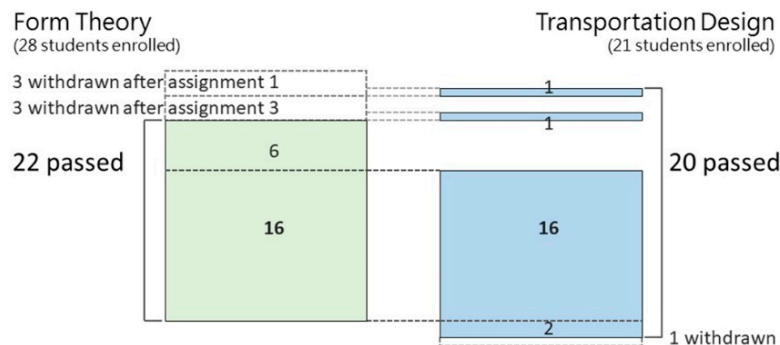


Figure 8. Distribution of the students enrolled in the two courses.

After each assignment, students’ self-assessments of their learning performance and learning responses were conducted to explore relevance with other assignments. In addition, we interviewed six students individually who withdrew from the course on Form Theory, and one student who withdrew from Transportation Design, to determine why they dropped out. They shared that they had dropped out because of a very heavy workload, as they had enrolled in many courses during the same semester, and not because they were disappointed with the lesson plans.

4.1. Results of Students’ Self-Assessments for the Form Theory Course

After the end of the semester, 22 students completed all four self-assessments. Each self-assessment was designed to display the context correlation between the assignments and factors of car styling (including proportion, contour, and volume for all assignments, and surface for Assignments 3 and 4), on a seven-point Likert scale (see Table 1; ‘strongly disagree’ = 1; ‘moderately disagree’ = 2; ‘disagree slightly’ = 3; ‘neutral’ = 4; ‘agree slightly’ = 5; ‘moderately agree’ = 6; and ‘strongly agree’ = 7).

Table 1. Questions in the self-assessments about the course on Form Theory.

No.	Question
Q1	My understanding of ‘factor’ has improved from before.
Q2	I have more confidence to deal with the ‘factors’ after finishing the assignment.
Q3	Dealing with the ‘factors’ in this assignment is helpful for the core design course.

In the general analysis (see Table 2), the result about Assignment 1 showed that ‘Q1 (improved understanding)—contour’ had the highest score (5.818), followed by ‘Q1—proportion’ (5.727), while ‘Q2 (more confidence)—proportion’ had the lowest score (5.272). For Assignment 2, ‘Q3 (helpful for the core course)—contour’ had the highest score (5.818), followed by ‘Q3—proportion’ (5.773), while ‘Q2—volume’ had the lowest score (5.045). The result of Assignment 3 showed that ‘Q1—contour’ scored highest (5.818), and ‘Q2—volume’ scored lowest (5.182). For the last assignment of the Form Theory course, ‘Q1—volume’ scored highest (5.545), followed by ‘Q1—surface’ (5.455), while ‘Q2—contour’ scored lowest (5.000).

Table 2. Mean of student self-assessment for Assignments 1–4.

Assignment	Factor	Q1: Improved Understanding	Q2: More Confidence	Q3: Helpful for the Core Course
1: 5.581 (0.794)	Proportion	5.727 (0.767)	5.272 (0.827)	5.500 (0.964)
	Contour	5.818 (0.664)	5.681 (0.646)	5.591 (0.959)
	Volume	5.681 (0.646)	5.364 (0.790)	5.591 (0.796)
2: 5.520 (0.927)	Proportion	5.500 (0.673)	5.227 (0.869)	5.773 (0.922)
	Contour	5.727 (0.985)	5.545 (0.912)	5.818 (0.733)
	Volume	5.364 (1.093)	5.045 (1.133)	5.681 (0.780)
3: 5.572 (0.756)	Proportion	5.636 (0.658)	5.591 (0.666)	5.773 (1.020)
	Contour	5.818 (0.588)	5.591 (0.666)	5.727 (0.752)
	Volume	5.591 (0.590)	5.182 (0.664)	5.545 (0.858)
	Surface	5.545 (0.858)	5.364 (0.848)	5.500 (0.740)
4: 5.295 (0.912)	Proportion	5.227 (0.869)	5.182 (0.733)	5.318 (1.086)
	Contour	5.409 (0.796)	5.000 (0.926)	5.364 (0.902)
	Volume	5.545 (0.789)	5.136 (0.834)	5.364 (1.002)
	Surface	5.455 (0.963)	5.136 (1.125)	5.409 (0.959)

Means for groups are displayed, and standard deviations are displayed in parentheses.

In the comparison of the first three factors of form generation (proportion, contour, and volume), the global analysis of variance (ANOVA) revealed no significant effects of the form factors for Q1 ($F[2, 252] = 1.269, p = 0.283$), Q2 ($F[2, 252] = 2.451, p = 0.088$), and Q3 ($F[2, 252] = 0.222, p = 0.801$). There was a significant main effect of the assignment for Q1 ($F[2, 252] = 2.727, p = 0.045$), Q2 ($F[2, 252] = 2.647, p = 0.050$), and Q3 ($F[2, 252] = 2.654, p = 0.049$). The interaction between the form factors and assignments was not significant (Q1: $F[6, 252] = 0.546, p = 0.773$; Q2: $F[6, 252] = 1.104, p = 0.360$; and Q3: $F[6, 252] = 0.154, p = 0.988$). Post-hoc tests (Duncan's multiple range test) for Q1 indicated that the understanding of form factors during Assignment 1 was statistically equivalent to that during Assignment 3, and both were more than that during Assignment 4 (both $p < 0.05$; see Table 3). Meanwhile, students' confidence of dealing with form factors after Assignment 3 was equivalent to that after Assignment 1, and both were more than that after Assignment 4 (both $p < 0.05$; see Table 4). The amount of learning from Assignments 2 and 3 was statistically equivalently helpful for the core product design course, and both assignments involved more learning than in Assignment 4 (both $p < 0.05$; see Table 5). According to the above results, the constraint and challenge in Assignment 4 were much higher than those in the other assignments. This might have been because of the application of a mirrored structure to the work in Assignment 1. Regarding the fourth form factor of surface (only in Assignments 3 and 4), ANOVA revealed no significant effects for Q1 ($F[1, 42] = 0.109, p = 0.743$); Q2 ($F[1, 42] = 0.573, p = 0.453$); or Q3 ($F[1, 42] = 0.124, p = 0.727$). This means that students could obtain the equivalent training of experiencing 'surface' from the last two assignments in Form Theory.

Table 3. Results of the post-hoc (Duncan) test for Q1 (improved understanding of the three form factors).

Assignment	N	Subset	
		1	2
4	66	5.39	
2	66	5.53	5.53
3	66		5.68
1	66		5.74
Sig.		0.310	0.137

Means for groups in homogeneous subsets are displayed, with data based on observed means. The error term is the mean square (error) = 0.594. Harmonic mean sample size = 66.000. Alpha = 0.05.

Table 4. Results of the post-hoc (Duncan) test for Q2 (more confidence to deal with the three form factors).

Assignment	N	Subset	
		1	2
4	66	5.11	
2	66	5.27	5.27
1	66		5.44
3	66		5.45
Sig.		0.242	0.231

Means for groups in homogeneous subsets are displayed, with data based on observed means. The error term is the mean square (error) = 0.668. Harmonic mean sample size = 66.000. Alpha = 0.05.

Table 5. Results of the post-hoc (Duncan) test for Q3 (learning to deal with form factors is helpful).

Assignment	Number	Subset	
		1	2
4	66	5.35	
1	66	5.56	5.56
3	66		5.70
2	66		5.76
Sig.		0.179	0.241

Means for groups in homogeneous subsets are displayed, with data based on observed means. The error term is the mean square (error) = 0.818. Harmonic mean sample size = 66.000. Alpha = 0.05.

4.2. Results of Students’ Self-Assessments for the Transportation Design Course

After finishing the project for Transportation Design, 20 students completed self-assessments in which we tried to explore the differences between idea sketching and clay modeling in experiencing the five factors of car styling, as well as their relations with the first four assignments. We used a seven-point Likert scale (‘strongly disagree’ = 1; ‘moderately disagree’ = 2; ‘disagree slightly’ = 3; ‘neutral’ = 4; ‘agree slightly’ = 5; ‘moderately agree’ = 6; and ‘strongly agree’ = 7).

According to the statistical analysis (see Table 6), students equivalently experienced the five form factors when learning idea sketching ($F[4, 95] = 0.335, p = 0.854$); however, they experienced different levels of form-factor learning during clay modeling ($F[4, 95] = 2.468, p = 0.050$). Then, post-hoc tests (Duncan’s multiple range test) revealed that students’ understanding of both volume and surface was higher than that of contour and detail after experiencing clay modeling (both $p < 0.05$; see Table 7).

Table 6. Mean of experiencing the five factors through Assignments 5 and 6.

Assignment	Proportion	Contour	Volume	Surface	Detail
5: Idea sketching 5.94 (0.827)	6.05 (0.887)	6.05 (0.826)	5.90 (0.718)	5.80 (0.834)	5.90 (0.912)
6: Clay modeling 6.00 (0.829)	6.05 (0.686)	5.95 (0.887)	6.30 (0.657)	6.15 (0.671)	5.55 (1.050)

Means for groups are displayed, and standard deviations are displayed in parentheses.

We also asked the 16 students that had passed the Form Theory course to recall the first four assignments and evaluate whether they were helpful for their AED project (see Table 8). The result of the paired samples test showed that these students felt that AED had statistically stronger correlations with the first two assignments than with the last two assignments of Form Theory (see Table 9).

Table 7. Result of the post-hoc (Duncan) test for Assignment 6.

Factor	N	Subset for Alpha = 0.05	
		1	2
Detail	20	5.55	
Contour	20	5.95	
Proportion	20	6.05	6.05
Surface	20		6.15
Volume	20		6.30
Sig.		0.066	0.216

Means for groups in homogeneous subsets are displayed. Harmonic mean sample size = 20.000.

Table 8. Correlations of Assignments 1–4 with automotive exterior design (N = 16).

	Assignment 1	Assignment 2	Assignment 3	Assignment 4
Mean (Std. Deviation)	5.00 (0.894)	4.81 (0.834)	6.19 (0.655)	6.00 (6.32)

Table 9. Paired samples test of the correlations between the assignments and automotive exterior design (N = 16, 95% confidence interval of the difference).

Pair	Mean (Std. Deviation)	Std. Error Mean	t-Value	df (Degree of Freedom)	Sig. (Two-Tailed)
AED_Asg.1- AED_Asg.2	0.188 (0.911)	0.228	0.824	15	0.423
AED_Asg.1- AED_Asg.3	-1.188 (0.981)	0.245	-4.842	15	0.000
AED_Asg.1- AED_Asg.4	-1.000 (1.095)	0.274	-3.651	15	0.002
AED_Asg.2- AED_Asg.3	-1.375 (0.806)	0.202	-6.822	15	0.000
AED_Asg.2- AED_Asg.4	-1.188 (0.834)	0.209	-5.694	15	0.000
AED_Asg.3- AED_Asg.4	0.188 (0.750)	0.188	1.000	15	0.333

AED = automotive exterior design.

5. Discussion

In this study, six assignments were designed to familiarize beginner AED students with the five factors of car styling. We attempted to discuss the learning effects of the five factors according to the results of statistical analysis, and found that students of the Form Theory course had no significant learning gaps among the first three factors: proportion, contour, and volume. Similarly, the fourth factor (surface) did not affect the students' understanding and confidence of form generation between Assignments 3 and 4. However, students in the Transportation Design course had different experiences of the five factors, especially when they made 1/8-scale models using clay (Assignment 6). Through clay modeling, the experience of volume (3D factor) became significantly stronger than that of contour (2D factor). The experience of another 3D factor, surface, was also stronger. This revealed that clay modeling is helpful for beginner students to gain a sense of 3D factors. Thus, learning through clay modeling can be considered a necessary process for learning AED.

Regarding the learning effects of the six assignments, Assignments 1 and 3 offered students better understandings of the factors and elicited higher confidence. Assignment 2 was considered to be the most helpful training for the core (product) design course. This clearly indicates that it would be helpful for the training of product design to include tools (or objects) and their functions. In the results of self-assessments for the first four assignments, Assignment 4 elicited the lowest score for every question. However, students thought that Assignment 4 (and Assignment 3) had a closer relation with learning AED. This indicates that creating a symmetrical speed form based on the existing structure was really difficult for beginner students. However, creation of the symmetrical speed form is very common in AED. We believe that the challenge of Assignment 4 is necessary for learning AED. Regarding the Transportation Design course, most students thought that they needed more time and practice to become familiar with AED, not only for idea sketching (13 students, 65%) but also clay

modeling (14 students, 70%). Additionally, five students responded that the 1/8-scale model was too small to incorporate specific details.

Experienced automotive exterior designers often deal with the volume, surface, and detail of car styling after the proportion has already been confirmed (at the beginning of projects). In the Department of Industrial Design (or Product Design), the Transportation Design course was very novel and interesting for beginner students of AED. However, although proper ambiguity of constraint would be helpful for experienced designers, this is not the case for novice designers and beginners [30]. Therefore, the difference between learning about basic form generation in industrial design and AED should be clarified to build module or preparatory courses for beginner students of AED. Thus, we summarize our suggestions for future courses and beginner students of AED as follows:

1. Remove Assignment 2 in this study if the learning goal does not include product design.
2. Reinforce the training of basic form factors, especially volume and surface.
3. Extend the duration of Assignment 4 to offer students more time to get familiar with the task.
4. Choose a bigger model to ensure students can include more sophisticated details as much as possible, such as at least a 1/5 scale.

A limitation of this study is that we do not address the students' original design ability. AED is a very professional field, and there is always a higher demand for automotive exterior designers' aesthetic abilities. It takes longer to train an automotive exterior designer than a normal product designer. Thus, this study only focused on examining the self-assessments of beginner AED students. Moreover, although collaborative teaching with AED experts was applied in the Transportation Design course, it may not have been enough for beginner students to enroll in a one-semester-only course. We will try to extend the AED course to a one-year (two-semester) course for the next year and carry out the abovementioned four improvements.

6. Conclusions

This study developed six modular assignments for design students to begin learning AED for the first time. The visual attractiveness of a product form can be considered as a most elusive and intangible quality [12], and this characteristic is much more obvious in the field of AED. Ideally, beginner students of AED should be guided to complete the preparatory course of basic form generation to enhance their skills and knowledge about car styling. From the perspective of design education, design students should have a very good command of basic form generation. By examining students' self-assessments and subsequent statistical analyses, we found that factors of volume, surface, and proportion were the most related to AED. Furthermore, there were obvious differences between learning basic form generation (product design) and AED. According to the results of Assignment 2, when teaching product design it would be more helpful to ask students to deal with the functions of tools. Moreover, training to deal with the factor of surface, which was not included in Assignment 2, was found to be more related to the learning of AED than the other factors were. It was also revealed that experienced product design students were not used to dealing with surface under the existing limitation of structure and volume. We hope that students in the near future will acquire enough skill, knowledge, and expertise from the improved module courses. Moreover, this was a quantitative study, and qualitative methods should also be used in the future to obtain more data about learning AED. We hope that a more sophisticated course design will be implemented in the coming years, and that research on the training of surface and volume will continue to develop.

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