Experiential Learning in Daylighting Course through Performance Measurements

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Abstract- The main objective of this study is to adapt research studies on performance measurements for daylighting design to education. An experimental course has been introduced in Missouri University of Science and Technology, and the curriculum was developed by including active learning beside the traditional learning environment. The parameters used in the schematic design and design development stages are presented, and the curriculum topics and practical experience are explained in the study. Particularly performance measurements are associated with course assignments. Curriculum results are evaluated qualitatively with assignment results and quantitatively with surveys. Current and emerging metrics are included in lab assignments and results of course assessments show that emerging metrics in daylighting technology and practical experience had attraction over participants. As a result of the evaluation of two sample courses, differences emerge regarding the courses that can be given at undergraduate and graduate levels. These differences are grouped into traditional lecture learning environments and experiential learning environments. The learning outcomes of the course curricula are summarized as gaining the knowledge and skills to communicate technically at the level of design practitioner for the student aiming for undergraduate graduation and at the level of the research community for the student aiming for graduate level.

Keywords: Daylighting, Performance measurement, Experiential learning, Course curricula

1. Introduction

A significant impact on the energy performance of a building can be provided by applying daylight-focused design parameters [1]. A well-designed day-lit space does not need excessive artificial lighting and energy consumption loads [2]. A well-daylit space is mainly illuminated with natural light. It combines high occupant satisfaction with the visual and thermal environment with low overall energy use for lighting, heating, and cooling [3]. The lighting quality concept contains several parameters regarding human needs, economics, the environment, and architecture. The proper balance of these (sometimes conflicting) dimensions aids to succeed good lighting quality [1]. Daylighting and view credits are also available in green building rating systems. Plenty of certified buildings have these credits with LEED certificates because daylighting is a core sustainable design consideration [4].

In order to make daylight and sunlight analysis for a building, there are many tools to be used. But, the use of tools is mostly not included in a building design budget and is thought to be the specialists' domain. Moreover, performing these studies as part of a design studio is not commonly promoted among architectural students [5]. As a teaching exercise for students to intuitively understand contemporary daylight performance metrics, daylight designing also has significant educational value [3]. In a 2010 US survey of 220 architectural, engineering, and construction (AEC) firms, the "biggest emerging concerns" experienced by the building industry were climate change and sustainability. The same survey reported by the participation of deans and department heads of 126 academic architecture programs that strengthening their sustainable design course offerings had been the most substantial change in their curricula over the previous five years [4]. The International Energy Agency, Solar Heating and Cooling Programme (IEA and SHC), commenced Task 41: Solar Energy and Architecture in 2012. The released Task 41 aims to clarify barriers that architects face with solar building design at the schematic design phase, maintain documents for handling obstacles, and aid in developing communication within involving sides [6].

The luminance-based techniques are mostly popular within the research community for application, and design practitioners have not given sufficient attention to these metrics. Consensus-based design recommendations for design practitioners are not supported by adequate research till now [7]. Hence, identifying the strengths and limitations of existing and emerging metrics and continuing research on developing luminance-based metrics are very important [1].

Current and emerging daylighting metrics aid design practitioners during early design phase and design development phase. The problem according to hypothesis of this paper is; these metrics are popular among research community not in design practitioners. The hypothesis and problem definition let us to think on the research question; how research results of current and emerging metrics can be adopted into the education. This paper is mainly seeking for curriculum development for daylighting course which will help recent graduates to gain ability on performance measurement on daylighting design.

2. Curriculum Development with Daylighting Performance Measurements

Emerging metrics beside current metrics, make more complicated measurement of daylighting performance of a building which needs expertise in different fields such as; computer simulation, photography, solar path etc. As a research field, integration of these diverse performance measurement tools needs further study which means open to new researchers. The daylight metrics can be categorized in two schematic or early design phases, and the design development phase is derived from the traditional project development process. One more phase can also be named post-occupancy evaluation, which uses similar metrics. Several research studies have been done so far for the first part, but there is not a common consensus and popularity yet in practice for the second part. Hence, assignments focused on current and emerging daylight metrics. Based-on motivations on research background, a daylighting course part of sustainable design and smart living would provide valuable perspective to architectural engineering education. Learning objective of daylighting course is to understand appropriate and verified luminance-based metrics of daylight modeling in building and each performed assignment shows a significant step towards this main objective.

2.1 Course Variables

Curriculum development was initiated for an experimental course with 3 credits at undergraduate/graduate levels in a Midwest Public University Architectural Engineering Program. Active learning is engaged along with traditional lecture learning environment and assignments are generated accordingly. One semester of experiential courses provided students with envisioning these metrics, tools, and possible results. Four undergraduate students enrolled in this experiential course who help a lot to developing curriculum materials. Once it was developed, course documents were used in a typical elective course in another institution with a large number of participants, with 81 students. Hence, two courses are named in this paper as one is an “experiential course” with a low number of participants, and the other is a “typical course” with a large number of participants. Basically, course 1 targeted to develop a new course and course 2 targeted to test the developed curriculum in a large number of participation of a typical course. Course variables belong to mentioned these two courses are introduced in Table 1.

Table 1: Course variables

Daylighting	course type	compulsary or elective	course delivery	total hours	lec-lab hours	number of assignm.	student number
Course 1	experiantial	elective	face-to-face	3	2 - 1	6	4
Course 2	regular	elective	online	2	2 - 0	2	81

Performance measurements are grouped as schematic design and design development which is retrieved from research community and these activities are assigned for students as lab activities. Active learning by real life problems are engaged in these activities. Six assignments were engaged in experiential course by students during lab hours as depicted in Table 2. Students are performed these activities to develop their assignments or case studies.

Table 2: Daylighting metrics during schematic/early design and design development phases

Active Learning by Real Life Problems				Development of Assignments / Case Studies
Schematic Design	1	**Solar path analyze**	Lat./longt., azimuth/altitude and magnetic decl.	⇨
			Stereographic sun path diagram	
			Orthographic projection	
	2	**Massing studies & daylighting metrics**	Daylight feasibility test	⇨
			Window to floor area ratio (WFR)	
			Daylight factor (DF) analyze	
	3	**Sunlight shading calculation**	Obstruction mask	⇨
			Glazing shading mask	
			Obstruction and sun position	
Design Development	4	**Computer simulation**	Daylight factor (DF) analyze (computer-based)	⇨
			LEED daylighting analyze report	
			False color rendering for illuminance	
	5	**HDR imaging technique**	Camera calibration	⇨
			Image capture with regular and fish eye lens	
			Picture merge with software	
	6	**Heliodon analyze with physical model**	Physical scaled model and sun-dial assembly	⇨
			Heliodon set-up	
			Shadow mask and luminance measure	

3. Methods of Performance Measurements

In building design, some basic information about natural lighting is needed to influence the design. Various performance measurement methods are used to determine the natural light levels in a building. These methods can be used before the construction of the building, during the design phase, and after the construction. These measurement methods are grouped under six headings: solar path analysis, massing studies, sunlight-shading calculation, computer simulation, HDR imaging technique, and Heliodon analysis. The information obtained from the proposed measurement methods will be used in different phases of the design, and the design phase is divided into two for professional practice, schematic design, and design development phases.

3.1 Schematic design phase

In the schematic design, the daylighting-building relationship is analyzed, especially according to the terrain and the location of the building on the land. At this stage, general data on natural lighting that will guide the building mass and its spatial design are tried to be revealed. Facade-space relations are analyzed according to the direction of movement of the sun. It is investigated how which directions affect the natural lighting levels of the spaces to be designed.

- *Solar path analyzes;*

The intensity of solar rays hitting a given building area can be estimated for different periods, and the negative impact can be managed and solved by design [8]. Solar path diagrams can determine or calculate the Sun's position in the sky. Furthermore, solar path diagrams are used in architecture to inform how the sun will affect the building [9]. A sun path diagram is essential in determining the position and altitude of the sun [10]. The most used projection methods are polar (stereographic) and cylindrical (orthographic) projections as graphical display techniques [11]. Solar path diagrams are a suitable way to show the annual changes of the sun's position in the sky on a 2D diagram. The behavior of the sun's lighting and heating characteristics is affected by latitude and longitude [12]. Another development in solar angle calculation is computer-aided programs that can calculate the sun's elevation and azimuth angles, given the necessary data. One of these calculators is the web interface proposed by NOAA, where latitude, longitude, date and time are entered to get the necessary data [8] [10]. Stereographic diagrams represent the sun's changing position in the sky throughout the day and year [12]. The solar path diagram is a two-dimensional graphical representation of the sun's path for a given latitude across the hemispherical vault of the sky. The three-dimensional sky dome in the sun-path diagram is reflected on a 2D circular display of which the sun's path transforms a series of elliptical curves [11]. A two-dimensional plot of the sun's position in Cartesian coordinates, where the x-axis represents the azimuth angle and the y-axis represents the azimuth angle, is called orthographic projection [8].

- *Massing studies and daylighting metrics;*

It should be taken into account when designing lighting of a building that building layout and orientation can reduce the need for artificial lighting and thus increase user satisfaction. It is accepted that a building layout adjusted to the solar path should provide sufficient natural daylight through windows [2]. Use of rules of thumb and daylight factor as a metric are still popular during schematic design in current daylighting design practice [13]. Rule of thumbs get common acceptance during preliminary design phase of massing studies are atrium and top lighting rule of thumbs, sky exposure plane rule of thumb, window-to-wall and window-to-floor area ratios and window head height. Calculation of sky angle is a helpful tool for daylight feasibility test. Building owner, architects and engineers should discuss the overall lighting design and user comfort objectives at the Preliminary design stage. A more general rule of thumb can be derived from the so-called daylight feasibility test. The basic idea is that in order for a sidelit space to be daylit, a minimum amount of daylight flux has to be able to enter the space through a window [4]. The percentage ratio between indoor illuminance and outdoor horizontal illuminance at a work plane under overcast sky conditions is called the daylight factor (%DF). This ratio used to measure and evaluate the presence of daylight in buildings is actually a fairly simple method [14]. Illuminance levels at desk height along the gridline of a space is measured to provide on-site data and this grid also helps illuminance mapping during digital analysis [3]. It can be calculated on a grid, plotted as a counter map, or averaged across a grid and reported as average DF [15]. The simplicity of the DF method let it enter into the building regulations in countries. It can also be used at physical models or post-occupancy of a building with illumination meters [16].

- *Sunlight shading calculation;*

Sunlight shading calculation can be performed by solar site evaluation, obstruction mask and glazing shading mask. Stereographic diagrams can be used by superimposing them on a field photograph taken with a fisheye camera. These two overlaid documents provide information on the times of the day throughout the year when the sun is blocked by buildings or vegetation and the times of shading [8]. A solar path diagram can also be attached digitally on a fisheye image with SunPath software. The time period when the relevant project area receives direct sunlight is determined with this superimposed image. Furthermore, these images are also used to assess how suitable a given area is for installing photovoltaic panels, solar hot water panels, outdoor seating, plants, etc [17]. The shading period of a year is pointed on the sun path lines as an obstruction mask [8]. The profile angle is needed to determine the position and size of the projections on the building mass and façade, to understand the length of the shadow they cast, and to grasp how they affect the space [18]. Today, overheating in office buildings designed with large window areas is a problem that needs to be solved in terms of building energy efficiency, even in cold climate zones. In building design, it should be remembered that solar radiation will result in significant cooling demands during the hot period and reduced heating demands during the cool period [19]. Increasing the size of a window allows for more light in the space, but simultaneously increases thermal loads. How to solve two opposing effects in a balanced way is an important design problem [4]. Solar shading systems are proposed as a solution to reduce the cooling energy demand of the building.

3.2 Design development phase

After determining the general positioning of the building with schematic design, there is a need for more detailed analysis to understand the natural lighting levels of the designed spaces more clearly, and solutions to this need are sought in the design development phase. At this stage, the focus is no longer on the mass of the building, but on whether the natural lighting levels of the spaces are sufficient.

- *Computer simulation;*

The performance of a building in terms of illuminance level in the design of a building should be examined taking into account different sky conditions and times of the day/year. For this, computer simulations are used widely [1]. Developments in computer software and the popularity of BIM have brought a different perspective to the subject. Research in integrating BIM with building performance tools has been a focus of both BIM software developers and users [20]. Features such as sun path, sun settings, shadow intensity are also integrated into Autodesk Revit, a BIM software [6]. On the other hand, independent of BIM, DF analysis and false color rendering visualizations can be performed with software such as the Velux daylight visualizer [21]. In addition to these widely used lighting simulation and analysis tools, some specialized software is also used by lighting analysts in research community [22]. For a building to receive credit for IEQ (Indoor Environmental Quality) 8.1, it must achieve a minimum daylight factor of 2% in 75% of all areas used for "critical visual tasks". The US Green Building Council's LEED green building rating system recognizes a daylight or glazing factor of 2% as a minimum reference level. Version 3.0 of LEED specifies a minimum light level of 25 footcandles (269lux) under CIE clear sky conditions from 9 am to 3 pm at the equinox [3]. The LEED calculations and/or computer simulation model should be developed in more detail during the preparation of the construction documents to verify the appropriateness of the design [23]. Autodesk Revit provides users LEED daylighting analysis report by lighting analysis add-in on cloud service. DF analysis on layout, a report shows passed or failed based on selected threshold, a detailed schedule of each room with lighting analysis are automatically created by running this software. Images that depict a scene using wavelengths in the visible region of the spectrum are called true color images. false color images show colors at one or more "invisible" wavelengths. Many types of radiation are invisible in the electromagnetic spectrum, so it is possible to see reflected energy in false color images [24]. It is often a good idea to present numerical results using a false color scale [25].

- *HDR imaging technique;*

High Dynamic Range (HDR) imaging enables one to record a scene of wide luminance range by merging a series of photographed images at different exposures [26] [27]. HDR imaging technique is also called radiance map or luminance mapping when used for luminance analysis. This technique is frequently used in different fields such as road and pedestrian lighting, spatial visual comfort, illuminance and glare analysis [1]. Scenes with high dynamic range – the difference between the brightest and the darkest areas - are not possible to be recorded without loss of details and texture in dark parts (due to underexposure) and in bright parts (due to overexposure) because the digital sensor's limitation in high dynamic range recording. These images are created by merging multiple images of the same scene, each of which has been taken with different shutter speeds, thus providing a better range of images with different exposures [28]. An HDR image accurately capture a physical scene's lighting data and "match human perception" of a scene [29]. The human eye can see a broader range of light than a digital camera can capture or than a computer screen can display [30] [31] [32] [33]. The human eye can see 24 different stops of light difference. Cameras, however, only make instantaneous exposures, with film and expensive medium format digital cameras being able to capture 12 different stops of light variations, while most other digital cameras can only capture about 5 stops of light variations or even less [28] [34]. Most current digital cameras have 5-20 megapixels, often cited as falling far short of our own visual system. This is because at 20/20 vision, the human eye is able to resolve the equivalent of a 52-megapixel camera (assuming a 60° angle of view) [32]. An HDR image is merged from an appropriate exposure range of photographs using a free software program (e.g., Radiance, Photosphere, HDRgen, HDRscope) [35].

- *Heliodon analysis with a physically scaled model;*

Physical models are the best way to evaluate the designs that are developed since there is virtually no scale factor for lighting in scale models [36]. A heliodon is an architectural design tool that physically simulates sun angles in reference to a surface. Altering a light source's position relative to the surface can simulate any global latitude, date, and time. Heliodons can be used outdoors or indoors [5]. So far, the heliodons for indoor development could be broadly categorized into two categories; the fixed sun-moveable earth model and the fixed earth-moveable sun model [37] [38]. These heliodons are mechanical devices and can be operated by manually or automatically [5]. Mechanical heliodons with fixed and moving tables need expertise and several types are produced and used in research centers and Universities around the world. Sky modeling and sun modelling can be generated for indoor heliodon. Sky modeling with a "mirror box" allows to simulation an overcast CIE (International Commission on Illumination) sky condition and thereby evaluate the daylight factor at any area of the modeled building [6]. Luminance measure can be performed on physical model if model have sufficient size to locate sensor inside [39]. Material type, reflectance values and sealing shall be paid attention during assembly of physical scaled model to get accurate indoor luminance level. Adjustable overhang, roof attachment, south, east or west overhangs, fin attachment, skylight attachment and clerestory attachments can be tested on a base building model [40]. In order to use a heliodon outside, a sundial is necessary to follow the sun path. [41]. "Shadows" computer program helps to produce and print-out easily a sundial relevant any specific latitude on earth [42]. Creating a shadow mask will be practical by using a portable heliodon with sundial for an outside heliodon. In these circumstances, sun is the light source and heliodon is a tilt-up table for physical model as moving earth model. The effect of clear sky over massing study results in shadow and this shadow mask can be measured at a given latitude and any time.

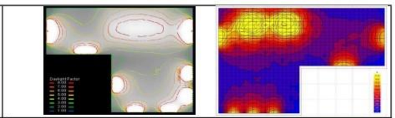
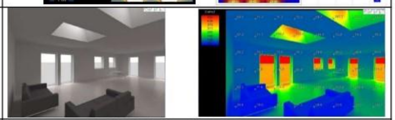
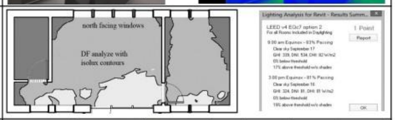
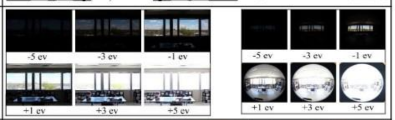
4. Results of Course Activity

An experimental course curriculum over daylighting technology has been developed and included current and emerging daylighting metrics into the assignments as lab activity. The activity carried out is evaluated qualitatively and quantitatively. Qualitative assessment is done by examining the outputs obtained from the assignments, while quantitative assessment is done by surveying the entire course curriculum and getting feedback from the students. It is thought that both evaluations will provide data for possible curriculum development. Likewise, in the light of this data, from experiential course to typical course has been reached. The development of the syllabus was divided into modules, and the survey for student feedback was designed according to these modules. For example, module A focused on the condition of the course materials, module B examined the traditional learning environment and module C evaluated the results of the experimental course environment.

4.1 Assignment results

Especially the assignment outcomes obtained in the experiential course are presented in this section. Experiential learning environment is created by implementation of these assignments and this is grouped under module C. This module covers performance measurements used in both schematic and design development phases. Results of design development phase in experiential course is depicted in Table 3.

Table 3: Assignment results of design development phase in experiential course (Course 1)

A. Computer Simulation	DF analyzes on sample layouts produced in experimental course (37N; overcast sky; March 21; 12pm-noon); Velux daylight visualizer (left); Ecotect (right).	
	Luminance mapping of a sample interior space produced in experimental course (37N; overcast sky; March 21; 12pm-noon); true color visualization (left); false color rendering with luminance mapping (right).	
	DF isolux contours on building layout by Autodesk Revit lighting analysis for 37N/91W (left); sample of result by Autodesk Revit cloud service (right).	
B. HDR Imaging Technique	Multiple exposure at interior of architectural design studio, produced in experimental course (left; 6 exposures with regular lens, right; 6 exposures with fish eye lens)	
	HDR image of 6 exposures with regular lens (between -5 ev and +5 ev) (center); HDR image of 6 exposures with fish eye lens (between -5 ev and +5 ev) (right).	
C. Heliodon Analyze	Sample of shading mask for 37N produced in experimental course (Dec., March, June 21 - 2pm).	

Accordingly, a comparison of assignment workloads according to course type is made. Considering the amount of time students spend on homework in these elective courses, a reasonable amount of homework is targeted. From this point of view, the same amount of time and effort is not possible in the regular course for a smaller number of students in the experiential course. Therefore, there is a difference between experiential and regular courses. In the experiential course all six assignments are completed in one semester, while two in the regular course are completed. However, in the regular course, the general introduction and technical information about the other assignments are presented to the students theoretically. On the other hand, the major difference is in the delivery method of both courses. While the experiential course was face-to-face, the regular course was online including exams and homework submissions.

Table 4: Assignment number / intensity based on course type

Daylighting	Assignment					
	1 solar path analyze	2 massing studies	3 sunlight shading calc.	4 computer simulation	5 HDR imaging	6 heliodon analyze
Course 1	X	X	X	X	X	X
Course 2		X		X		

As it is directly related to spatial design, performance measurements in the design development phase are included here. When the place of the course in the general curriculum, credit-hour load, purpose, targeted learning outcomes, and homework outcomes, which are the end products, are evaluated together, it is decided in this section which assignments will be included in which type of courses (Table 4).

4.2 Survey results

Implemented teaching methodology along with course materials has been assessed by students. A survey was held at the end of semester including eighteen questions. First two questions were relevant to students' academic level and level of construction experience. Remaining sixteen questions belong to teaching methodology and course material. Questions are grouped under three categories; Module A-course content, Module B-traditional learning and, Module C-active learning. Question topics, grouping (modules) and numeric results of survey results are depicted in Table 5. Students rated the significance of each item by using a scale of 1 through 10 (with 1 meaning unimportant ……. and 10 meaning very important). In addition, average rate of significance of each question is shown in Table 6. The table provides to monitor strength and weakness of learning environments and course materials to enable instructor to do necessary revisions.

Table 5: Question topics, grouping and numeric results of each question for both courses

Module		Measured Course Material		Aver. Rate	Module		Measured Course Material		Aver. Rate
Module A	Course Content	A.1	Daylighting in sustain. build. design	9,00	Module C	Experiantial Learning Environment	C.1	Solar path analysis	8,75
				9,05					8,03
		A.2	Deylighting technology	9,50			C.2	Massing studies & daylight metrics	9,00
				8,49					7,78
		A.3	Daylighting design parameters	8,75			C.3	Sun shading calculation	8,25
				8,38					8,05
		A.4	Case studies presented in the lecture notes	9,25			C.4	Computer simulation	8,75
				8,16					8,30
Module B	Tradition. Learn. Envir.	B.1	Face-to-face lecture	8,75			C.5	HDR image technique	8,75
			Online lecture	6,89					7,84
		B.2	Reading (lecture notes)	7,50			C.6	Heliodon analysis on physical model	8,75
				8,51					7,68
		B.3	Face-to-face lab exer.	8,75			C.7	Final presentation by students	8,00
			Online exercises	8,19					7,57
		B.4	Paper based exam	7,75			C.8	Team work effectiveness	10,00
			Online exam	6,95					7,43

Results of Course 1 (white) — Results of Course 2 (grey)

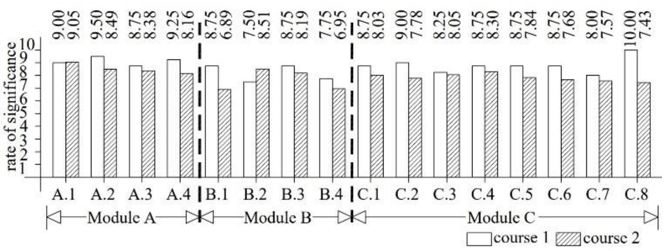
General attention and interest of students over course topics is observed in Module A-course content. The rate of significance of all topics in this section is measured always above 8 out of 10 in both classes. When we compare the results of both courses, the only increase in rates occurred in Module B-reading (lecture notes). This would have happened due to lectures notes were ready in regular course whereas it was under preparation in experiential course. On the other hand, the major decrease is observed in Module B section B1 and section B2 which are related with course delivery method as lecture and exam respectively. Moreover, another major decrease is obvious in teamwork effectiveness, but this one is negligible, because of having limited number and well-organized group of students in course 1.

Daylighting technology aroused students' interest and enthusiasm for practical experience. Therefore, an advanced case study may improve course material.

- **The survey results of course one** can be summarized as follows; Team-work effectiveness has the highest rate and reading (lecture notes) has the lowest rate per survey results. Daylight technology attracted students receiving 9.5 points out of 10. Presented case studies belong to previous research findings having 9.25 out of 10 shows that students' interest in practical experience. The final presentation was received less popularity as having 8 out of 10 as well, when compared with other items.

- **The survey results of course two** can be summarized as follows; Daylighting in sustainable building design has highest rate and online lecture has the lowest rate as per survey results. Reading (lecture notes) attracted students with receiving 8.51 points out of 10. Computer simulation having 8.3 out of 10 shows that interest of students over practical experience. Teamwork effectiveness was received less popularity as having 7.43 out of 10 in practical experience, when compared with other items.

Table 6: Average rate of significance of each question for both courses



5. Conclusion

Due to inclining trend over daylighting technology, a course curriculum is developed and active learning is engaged for assignments in lab. Boundaries of these activities shall be different based on course type. In the light of the data obtained from both course curricula, survey results and observations, it was determined that there should be a difference between undergraduate and graduate level courses. The level of differentiation in course types depends on the objectives and learning outcomes of the course. Likewise, the difference in the learning outcomes stated in the course syllabus is reflected in the assignments and course content. It is also related to the calculation of the weekly credit load of the assignments in the course for which the student is responsible. In addition, the objectives and learning outcomes of the regular course in the undergraduate program must be compatible with the program outcome. Therefore, not all course material developed in the experiential course can be applied to the regular course. Hence, suggestions are made in this section regarding course content and assignments.

- *Suggestions for assignments;*

In the evaluation of the outcomes of the assignments, the condition of the students when they graduate is considered. If they work as design practitioners, the question of which assignments are necessary for them should be decided. From this point of view, it is recommended that massing studies and computer simulation assignments should be included in the undergraduate curriculum where they can be widely used. On the other hand, at the graduate level, the main goal is to have a minimum level of technical communication within the research community at the end of the course. Therefore, it is recommended to include all six assignments in the graduate level syllabus (Figure 1).

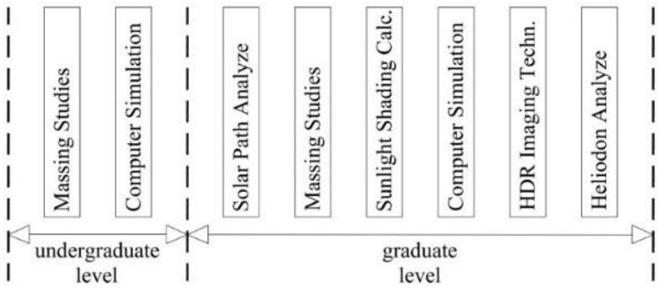


Figure 1: Suggestions for assignment content

- *Suggestions for course content;*

Similarly, the common differences in content between the research community and design practitioners should be reflected in courses at different levels. Two topics that are not common among design practitioners should be removed from the undergraduate course content. These proposed topics are photometry / HDR and heliodon / sundial. Instead, topic of static shading shall be expanded in weekly schedule.

Measures to indicate the effectiveness of learning activities and course material by survey show that daylighting technology and practical experience attracted participant students. Hence, curriculum development and result of survey shaped the necessity of advanced study over daylighting technology.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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