# Full spectrum computer-aided design: "To Infinity and Beyond"®

**Nancy A. Rudd and Hyunjoo Im**

**Abstract**

Apparel product development includes many subject matter components. As fashion educators, we recognize the rich variety of offerings and educational strategies used in teaching apparel product development. We will share some strategies that challenge the talents and creativity of our seniors in apparel product development. We offer a series of 3 capstone courses in computer-aided design: (1) beginning CAD, (2) advanced CAD and draping, and (3) product data management. Admission is through application only during the junior year, after students take courses in the fashion industry, aesthetics, textile science, sewn products analysis, and fashion illustration. Our students view this series as a 'full-time internship' without pay, since they develop 12 design collections in 9 months, all in teams. The result for students is a portfolio of 2-dimensional CAD work, draped designs of unusual materials which may be later shown in a public runway show, professional Powerpoint presentations to industry representatives, confidence, and team-building experience. Each project requires market research to position the line in a competitive market, trend research, company logo and design philosophy, plus design generation. By the end of the series, students will have designed for such diverse mass and niche markets as evening wear for women who have had breast cancer, ethnic markets, functional accessories, bridal, and adventure travel. The first course focuses on mastering software in image manipulation, technical draping, artistic rendering, fabric design, and color palettes. The second course explores pattern-making via draping, with accompanying technical production packages. The last course teaches production specifications via Gerber PDM software. In each course, a final project incorporates all of the software programs covered in a comprehensive market study and line creation, shown to industry representatives who attend the class

Keywords:
CAD (computer-aided design),
active learning,
critical thinking

presentation. Students see previous year's projects, and are challenged to travel beyond that level of creativity.

## Introduction

We believe that it is critical for students in a senior-level series of apparel design courses to integrate concepts of market research, need analysis, design generation, and production specifications. This series of three courses in apparel product development builds upon subject matter components that students have taken previously in their programs of study, including the fashion industry, aesthetics, textile science, sewn products analysis, fashion illustration, materials analysis, and socio/cultural aspects of dress. The means to the end of integrating these previous components into the capstone courses is to rely on *active learning* and *critical thinking* methods of teaching. Active learning engages the student on a personal level and encourages them to become involved 'actively' instead of passively, and to become emotionally and physically engaged in their learning. The goal of critical thinking is to move learning to a higher level and to move students beyond their own personal experiences and biases to a broader, more diverse perspective in their thinking, or from the familiar to the unfamiliar (DeLong, Hegland, & Nelson, 1997). In teaching these capstone courses, we find that students are frequently naïve and simplistic in their perspectives at the beginning of the series, but with structured encouragement and a variety of design challenges, they are anxious to adopt a more global and complex mode of problem-solving by the end of the series. Therefore, we would like to discuss the pedagogy that enables this transformation, as well as the types of experiences and outcomes that build upon each other.

## Active learning and critical thinking

Active learning 'actively' involves students in the learning process, meaning that it engages them in higher level learning tasks such as analyzing, synthesizing, and evaluating (Chickering & Gamson, 1987), as opposed to tasks such as memorizing, recalling, or paraphrasing information. Students apply what they have learned (Meyers & Jones, 1993) through activities that require them to talk, write, read and reflect, or solve complex problems. Writing position papers in response to a class video, discussing topics with a partner, and negotiating responsibilities and carrying out group projects are all examples of

active learning. While we know that students learn in different ways, active learning can be achieved when students become engaged in multidimensional projects requiring them to use knowledge to do something, critically think about what they have done, and evaluate it.

Structuring active learning into courses often requires more effort than engaging students in the more typical passive learning mode that is utilized in many college courses. While lecturing is the primary mode of instruction in most US college classes (Tsui, 1999), this mode of instruction is inadequate for courses that focus on the creative process. In these courses, such as apparel product design courses, students need opportunities to stimulate their creativity, to discuss and solve problems, and to reflect on what they have learned so that they can apply, and thereby reinforce, the knowledge gained.

Critical thinking is a rational response to questions that cannot be answered definitively and for which all the relevant information may not be available. It is defined by Kurfiss (1988), as "an investigation whose purpose is to explore a situation, phenomenon, question, or problem to arrive at a hypothesis or conclusion about it that integrates all available information and that can therefore be convincingly justified" (p. 2). A project requiring critical thinking will result in an outcome (a conclusion or hypothesis) and will provide a justification for that outcome. Critical thinking typically requires careful reasoning about problems that are open-ended or poorly-defined, and that have no single solutions (Kurfiss, 1988). This ability to bring knowledge and insight together from many sources to draw conclusions, or suggest new connections, can be fostered through active learning environments. Thus, critical thinking is the goal and active learning is the strategy in our capstone courses in apparel product development. We will discuss several of the graded activities that we developed to this end.

### Apparel product development models

Through each design project in these courses, we asked students to assume the role of creative designers within an apparel retail business, and to research and design an apparel line. Wickett, Gaskill, and Damhorst (1999) define retail product development as an integrative process leading to the creation of research-based private label merchandise by a retailer for sale to a specific target market. We examined apparel product development models to guide our active

learning and critical thinking projects. These models integrate the apparel product development process within the retail scenario (Wickett, Gaskill, & Damhorst, 1999) with the apparel design process models (Lamb & Kallal, 1992; Regan, Kincade, & Sheldon, 1997). We integrated the product development process with Computer-Aided Design (CAD) technology since this is critical in meeting the needs of mass market and niche market segments (Rudd, 1990). Each of these models stresses the importance of product line development in the context of needs and problem solving.

Wickett, Gaskill and Damhorst (1999) developed a Retail Apparel Product Development Model based on qualitative interviews among twenty-one specialty store retailers. This model describes four stages in the creation of the apparel product: research, line conceptualization, product visualization and evaluation, and technical development. Research includes identifying sources of inspiration such as travel, media and product competition, and how potential trends can influence the target market. Line conceptualization includes development of theme, color palette, structural fabric type and surface design, silhouette and style, prototype patternmaking, construction and analysis, and line presentation and adoption. Technical development involves perfecting fit, production pattern-making, materials and garment specifications, sourcing and costing.

Lamb and Kallal's (1992) framework for apparel design incorporates the functional, expressive and aesthetic (FEA) needs of the target consumer, who is at the core of all apparel design. They identify stages of design, including problem identification based on needs, generation of preliminary creative ideas, design refinement, development of prototypes, evaluation of prototype based on identified needs, and implementation of final designs. Regan, Kincade and Sheldon (1998) applied an engineering design process to apparel design and defined the following stages of design, which parallel Lamb and Kallal's model but provide greater specificity: (1) problem recognition (consisting of problem statement, generation of ideas and formulation of a solution); (2) problem definition (value and design direction, resources, design boundaries such as special needs, and related problems such as sizing; (3) problem exploration (consisting of information search, assumptions, design strategy, market assessment, objectives, and cost); (4) alternatives search (based on experience, answers, requirements and

design proposal); (5) evaluation of outcomes and feasibility; (6) solution specification based on analysis and optimal proposal; and (7) solution communication through verbal and visual means.

### Computer-aided design capstone courses

Our university follows the quarter system, in which courses are 10 weeks long plus a week of finals, so each course includes several projects done in teams and one final team project that is very broad in scope. In the first course, Beginning CAD for Apparel Product Development, students master different creative software programs:

- Adobe Photoshop (image manipulation to create a collection of print fabrics for a sportswear collection),
- Corel Designer (technical drawing to create a collection of two complete outfits of tailored wear suitable for office),
- Corel Painter (artistic rendering to create an evening or special occasion collection),
- Ned Graphics Easy Weave and Easy Coloring (fabric design and color palette development for a specific target market, sometimes using specialty fiber such as alpaca),
- Powerpoint (software to organize all software images into public presentation).

The final project integrates all of these programs, and requires teams to include construction details, specification measurements for a sample size, and materials specifications, in addition to a marketing plan, storyboard, and market/trend analysis. Final projects often include some data collection or interviews with current or potential target customers.

The second course, Advanced CAD and Draping, is experimental in nature, focusing on intensive draping instruction as a 3-dimensional means of pattern making, experimentation with unusual materials, and creating technical packages to accompany the designs. Most projects are completed in design teams of two or three, and teams of four or five for the final project. We use all of the software programs from the previous term, and introduce two additional programs:

- Ned Graphics Easy Knit (fabric design for knits)

- Ned Graphics Easy Drape (mapping a fabric design onto a 3-dimensional scanned body).

The third course, Product Data Management, focuses on mastery of the PDM software by Gerber Garment Technology. This software enables students to import images from the other creative programs into PDM forms and thus create technical packages that are production ready. Forms that we utilize include style summary, free forms (ex., fabrics, color palette, sourcing), graded measurements, how to measure, and construction details.

### Software and projects

We will share examples of projects in each of the three courses. Because each course is 10 weeks in length, we usually assign 4 projects. The projects assigned when learning the software are due every week or ten days, whereas the final project is allotted four weeks. Thus, the pace is very fast and students have no choice but to be actively engaged in both creative and technical aspects of the projects.

#### Beginning CAD for Apparel Product Development

In the first course, we begin with Photoshop software. Students scan an image from a fashion magazine, a piece of jewelry, a fabric print, or anything else that can be scanned. They isolate one particular part of the image, alter it with a variety of tools, repeat the image, and fill a garment image with their fabric design. They do this with two or three times to create companion prints, some of which look more like solids, and complete a mini-collection of sportswear.

Then we move on to technical drawing using Designer software. Students practice various drawing tools by replicating the style and construction details of one of their own garments, with particular attention to accuracy of proportion, line width and line type, closures, facings and under-stitching, decorative stitching or other embellishment, and location of fit details such as darts or princess seams. After this practice, their assignment is to design a small collection of tailored wear (suits, jackets, coats, pants, and accompanying sweaters or woven tops.) They also develop a simple pattern or select colors to fill the images, and their projects include both the filled designs to simulate the final product and also the unfilled images that are critical to a pattern-maker.

The third project in this course utilizes Painter software for artistic rendering of an ornate and complex evening wear, bridal, or special occasion garment. One year we even designed Halloween costumes (and the daughter of one author saw the projects and asked her mother to make her the pumpkin evening gown, which was finally accomplished under great duress!). The goal of this project is to render creative and beautiful artwork using computer tools, and to develop skill using these tools while looking at the computer monitor rather than at one's hand as in more traditional drawing techniques. The variety of artistic effects is nearly infinite, since one can select a tool (e.g., watercolor) choose the type of brush (e.g., smeary bristle, heavy, fine), manipulate the brush size (very thin to very thick), manipulate the opacity of the stroke (very faint to opaque), and quickly change colors. In addition, one can build layers in the drawing, so if you want to try out flounces around the hem, that can be a separate layer which enables you to see the garment with and without this design feature. We encourage our students to make most design details on a separate layer, for ease in perfecting the drawing. For example, if you don't like the fabric or perhaps the hair of the fashion figure, you can simply delete that layer and begin again. Another great feature of this software program is creating one design detail, copying it, flipping it, and moving it into place on the other side of the body. Also, this program offers many special effects, such as "fairy dust" to add sparkle to sequins or eyes, and nozzles that can be loaded with a design such as 'roses' or 'ivy' to create delicate jewelry or background designs.

Easy Weave is software that is used to create and simulate fabrics. For example, you can choose a pre-designed fabric weave from the extensive atlas of weaves (e.g., twill, herringbone, piqué, complex weaves) or create your own custom weave. Individual yarns in both warp and weft directions can be colored using an infinite array of 16 million colors (256 on the screen at one time). Then, using settings of shading, material, and contrast, you can simulate the fabric; various combinations will allow you to preview your weave as a heavy wool melton, or a silk charmeuse, and so forth. The project utilizing this software is to create a series of four different fabrics that are related in design and color, to create a collection for a specific target market. Examples have included fabrics for kids' sleepwear, alpaca outerwear, denim sportswear, and pet coats. Students provide technical drawings with their fabrics filled

in. We often require the use of Easy Coloring software along with this project, so they can provide alternative color palettes for their fabrics.

The final project is a creative application of all software learned in this course. It provides an opportunity to design a collection to meet a specific need or target a specific audience, and thus requires market research to position the line in a competitive market, and trend research on colors, fabrics, and style details. It may also require interviews with members of that market segment to gather data on specific needs and desires, as in the case of women who have had breast cancer surgery or athletes who compete in extreme sports, or elderly consumers whose dexterity and health may be impaired. A few examples of final projects include:

- bridal wear,
- elderly consumers who travel or are engaged in leisure sports,
- charity and debutante ball gowns,
- active adventure wear,
- professional wear for conferences or business trips.

This project is conducted in teams of 4-5 students, who negotiate their responsibilities, write a contract, and evaluate each other at the end (this contributes to their final grade). The project includes the name of the product line, company logo, design philosophy and statement of target consumer and characteristics, price points, fabrics, and position map of competitors. The design collection is generated by all group members, with each contributing at least 3 sketches. From those sketches, three garments are selected for artistic rendering and technical drawings of both front and back views. Fabric designs are generated, along with color palettes for each design. Measurement specifications and all construction details are also provided for one garment; accessories are scanned in for each garment to provide an idea of what the collection might look like on the runway. If students choose to add extra garments (which they frequently do), extra credit is given.

Students present these final projects to the class, any other interested faculty, and invited industry guests, which may include creative or technical designers, or human resources personnel. Students use Powerpoint software to organize all software images into this public presentation.

### Advanced CAD and Draping

This course teaches design by draping for the first four weeks of the ten week term, focusing on basics of shaping devices, controlling fullness, asymmetrical designs, and silhouettes. During this time, students drape on half-scale or full-scale dress forms in muslin fabric. Then we move into a three week period in which they design two garments in teams, one on a dress form and the second actually draped on a class member. We strongly encourage experimentation with unusual materials, and creating technical packages to accompany the designs. Unusual materials include specialty fabrics, wire mesh, shower curtain, feathers, paper bags, ribbon, men's ties, and plastic food wrap, among others. Anything goes in this course, but garments must still fit the body and construction techniques must be adapted to the materials used (i.e., using a glue gun on plastics, molding chicken wire and inserting feathers.) As they create technical packages for these designs, they must include at least one original knit fabric and map the design onto a scanned body.

The final project is completed in groups of 4-5 students, and typically focuses on a select design problem, which might be unusual construction details or incorporating design features from another culture or historical time period. Students must turn in a half-scale or full-scale garment in addition to their technical package.

### Product Data Management

This last course utilizes the Web PDM software by Gerber Garment Technology, but because this software is comprised of numerous forms to enable companies to transmit production information to manufacturers, it is rather boring to focus solely on the forms. Therefore, we have developed projects that build upon the previous software capabilities of Photoshop, Designer, Painter, and Easy Weave, Easy Knit, and Easy Coloring and incorporate images from these programs into the forms. We usually have two smaller projects plus a final project; each project has creative, technical, and production components. The outcome is technical packages for each design collection. Projects in this course have included:

- functional accessory design (ex., jewelry with hidden asthma inhaler or body sensors) yoga mat carrier with compartments for clothing, cell phone, water bottle, etc.),

- home or personal fragrance bottles and packaging,
- purses or bags,
- plush animals and basket designs for personal care items.

The final project typically focuses on a niche market segment, which might be clothing for autistic children, maternity wear, exercise wear, rainwear, urban streetwear, etc. In addition to all of the PDM forms necessary for production, students prepare a detailed project with creative drawings, technical drawings, fabric designs, colorways, accessories, market research and trend research, description of target market, and a marketing plan.

### Outcomes

Through this capstone series, we cover the full spectrum of computer-aided design, from design generation to production. Team-work creates a collaborative environment in which students negotiate design ideas, details, balance of work, and layout of the submitted project.

It is not at all unusual for the class average at the end of the term to be an A, which thrills us. We always provide extra credit for additional work that is well done (but not for poorly executed additional work), and we believe that working in design teams challenges students to be more competitive and creative. Each project requires that students pair up with a new partner, which we hope creates camaraderie and support among class members. We preface the series of courses with a discussion of building their professional network in these classes; they will probably be connected to some of their classmates for years into the future, so we expect them to develop those connections now and work hard to develop solid working relationships with everyone in the class. We also explain that they will be working with a wide variety of individuals in their careers, and not everyone will have the same work ethic or ideas they have. Thus, they need to negotiate with each other throughout the term, and find 'win/win' solutions when disagreements arise. We make it quite clear that we are not there to resolve disputes, but to guide them and give them professional advice. We will look at any design or project before it is turned in to offer free advice on accuracy, design quality, materials, construction decisions, etc., but once it is submitted, then the grade becomes the final evaluation. Some students take advantage of this input consistently, but others prefer to work on their own with little input.

We structure our courses following active learning pedagogy; students are actively engaged in the process of learning various computer-aided design software programs over the course of 9 months. Students are engaged in analyzing, synthesizing, and evaluating information as they design apparel products for various market segments and price points. Analyzing occurs through the process of analyzing market or design trends, analyzing customer functional or aesthetic needs, and analyzing what steps are needed in the creation of original designs, technical drawings, and production information. They also analyze, both individually and within their teams, what needs to be revised based on their own evaluation or feedback from the professors. Synthesizing occurs through the application of previous coursework in their materials selection, color palettes and color naming, construction details, and marketing strategy. Evaluating occurs through the constant evaluations of design details (both aesthetic and functional), evaluating what more needs to be accomplished in the scope of the project or what additional work they can add to show off their creativity and drive, and evaluating on paper one another's contributions to their final projects. We do not rely on memorization, recall, or paraphrasing of previously acquired information. Instead, students apply what they have learned through activities that require them to talk to each other or potential clients or faculty members, read and reflect on trend reports or other market information, present written and visual reports that are cohesive and creative, and solve complex design problems. We structure the projects to engage them emotionally in their learning, and the pace at which they work engages them physically. The CAD lab is a very busy lab during class, and usually during open lab hours as well. We open the lab on weekends toward the end of the term to provide them with additional opportunities to work.

Critical thinking is the backbone of these capstone courses, as we engage them in multidimensional projects requiring them to use their brains and hearts to do something, critically think about what they have done, and evaluate it. Throughout the course of 9 months, students develop a CAD portfolio with about 12 design collections that cover a broad span of target audiences and CAD software programs. These design collections all require critical thinking and result in a specific outcome, along with a justification for that outcome. Because apparel product development is a process that requires critical

thinking, we believe that our students' portfolios provide evidence to future employers that our students are able to use careful reasoning about problems that are open-ended, may be poorly-defined, or may have no single solutions. Fortunately, as students have shown their portfolios to local companies such as Lane Bryant, Abercrombie & Fitch, Victoria's Secret, Hollister, Tween Brands, Bath and Body Works, and VESI, response has been most favorable. We have increased our program visibility among these local apparel companies; they have hired our students, sought us out for open positions and internships, and one company even created a new position for one of our students based on what they saw when attending a final presentation.

Students are definitely engaged throughout the capstone series, and while there are usually some frustrations, students report really enjoying the courses and being proud of their results. Student evaluations for the courses are high. From the perspective of the faculty member (myself and my teaching assistant), we are very actively engaged too. The amount of time involved in planning the projects, guiding students in their individual market research and line development, and grading is extensive. In an era where our contribution to the university is measured in terms of how many full-time equivalent units we generate, we don't make a very big contribution through these courses with only 30 students per term which is the limit imposed by the size of the CAD lab (15 workstations with two students per station.) However, as far as the students and local apparel industry companies are concerned, we have made a big contribution.

Each year the projects in these courses include various phases of the Retail Apparel Product Development Model (Wickett, Gaskill, & Damhorst, 1999) and Lamb & Kallal's (1992) conceptual framework for apparel design. We to continue to dream up different projects to meet the course objectives, and it keeps our creative juices flowing. Thus, it seems that there are really no limits in what our students can do within our computer-aided design courses, or as character Buzz Lightyear from the movie Toy Story would say, "To infinity and beyond."®

**References**

Chickering, A.W. & Gamson, Z.F. (1987), Seven principles for good practice, *AAHE Bulletin* **39**, pp. 3-7

DeLong, M., Hegland, J., & Nelson, N. (1997), 'Encouraging critical thinking in the classroom: An example from aesthetics', *Clothing and Textiles Research Journal* **15** (2), pp. 86-95

Kurfiss, J.G. (1988), 'Critical thinking: Theory, research, practice, and possibilities', *ASHE-ERIC Higher Education Report No.2* (Washington, DC: Association for the Study of Higher Education)

Lamb, J.M. & Kallal, M.J. (1992), 'A conceptual framework for apparel design', *Clothing and Textiles Research Journal* **10** (2), pp. 42-47

Meyers, C. & Jones, T.B. (1993), *Promoting active learning: Strategies for the college classroom* (San Francisco, CA: Jossey-Bass Inc., Publishers)

Regan, C.L., Kincade, D.H., & Sheldon, G. (1997), 'Applicability of the engineering design process theory in the apparel design process', *Clothing and Textiles Research Journal* **16** (1), pp. 36-46

Rudd, N.A. (1990), 'Computer-aided design applications to apparel fro special needs', in Rabolt, N. (ed.) C*omputer applications in textiles and clothing* pp. 21-25. (Monument, CO: Association of College Professors of Textiles and Clothing)

Tsui, L. (1999), 'Courses and instruction affecting critical thinking', *Research in Higher Education*, **40** (2), pp. 185-200

Wickett, L.J., Gaskill, L.R., & Damhorst, M.L. (1999), 'Apparel retail product development: Model testing and expansion', *Clothing and Textiles Research Journal* **17** (1), pp. 21-35

## About the authors

Nancy A. Rudd is an associate professor in the department of Consumer Sciences at The Ohio State University. She teaches undergraduate and graduate courses in apparel product development and the social psychology of dress. Her research area is body image.

rudd.1@osu.edu

Nancy A. Rudd, Ph.D.

Associate Professor

The Ohio State University
265 Campbell Hall
1787 Neil Ave.
Columbus, OH 43210
USA

Hyunjoo Im is a doctoral candidate in the department of Consumer Sciences at The Ohio State University. She is a teaching associate in the CAD lab.

Hyunjoo Im, Ph.D. Candidate
The Ohio State University
265 Campbell Hall
1787 Neil Ave.
Columbus, OH 43210
USA