

DIGITAL AGE DIDACTICS: FROM TEACHING TO ENGINEERING OF LEARNING PART 2*

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Abstract

The digital age demands re-thinking of traditional teaching and learning. Rapidly growing technological innovations in education force a paradigm shift from traditional teaching to engineering of learning. Thus, the main focus of the article is on the design, development, and implementation of effective learning environments through the use of Information and Communication Technologies in various formats: face-to-face, blended, and distance education. Engineering of learning requires new understanding and reconceptualization of traditional didactics toward e-Didactics in order to effectively design and skillfully align learning objectives, content, and assessment in the digital age classroom.

Keywords: didactical engineering, digital age, teacher-engineer, effective learning environment.

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Engineering of Distance Learning

There are different Learning Management Systems used by universities across the globe for designing and offering online courses. In this section, we will describe the main features of the Blackboard Learn system to engineer distance learning using as an example one of the courses the author teaches at the University of Texas at El Paso — MTED5318 “Learning Theory in Mathematics Classroom” (Figure 1).

The author has been using the learning management systems including Blackboard for designing and teaching courses in mathematics and mathematics methods for both pre-service and in-service teachers as well as graduate and doctoral courses in cultural-historical epistemology and learning sciences since 2005. As a designer and an instructor, the author is able to develop the course content, construct assignments, select ICT resources in connection with the course goals and objectives, design a system of monitoring and evaluating student progress, provide learning environment for student interaction (individually and in group) and communication using both synchronous (e. g., chat-room) and asynchronous modes (e. g., discussion board, blog, wiki).

The Blackboard Learn course environment consists of three main sets of tools: the Course Menu, the

Control Panel, and the Course Content. The Course Menu is central for the organization and navigation of the course and it is located on the left side of the course homepage. The designer uses the Course Menu tool to present the key links to the course materials such as “Getting Started”, “Announcements”, “Learning Modules”, “Assignments”, “Calendar”, “Discussions”, “Mail”, etc. The appearance and the order of the links could be customized by the designer using two views available to users: (1) the list view, which displays only the top level of course materials, and (2) folder view, which displays the course materials as a directory tree. The Control Panel is the course management tool, which consists of the following features: Content Collection, Course Tools, Evaluation, Grade Center, Users and Groups, Customization, Packages, and Help. The Content Collection is a repository of course files. Changes made to a file in this area will be automatically replicated to all of the courses where the file is used. The Course Tools includes communication, collaboration, assessments, and other tools available for use in the course. The Evaluation feature provides links to Course Reports, Performance Dashboard, and Early Warning to access the diagnostic information on student performance (e. g., activity and content usage). The Grade Center includes links to the assignments and assessments that need grading and the grade

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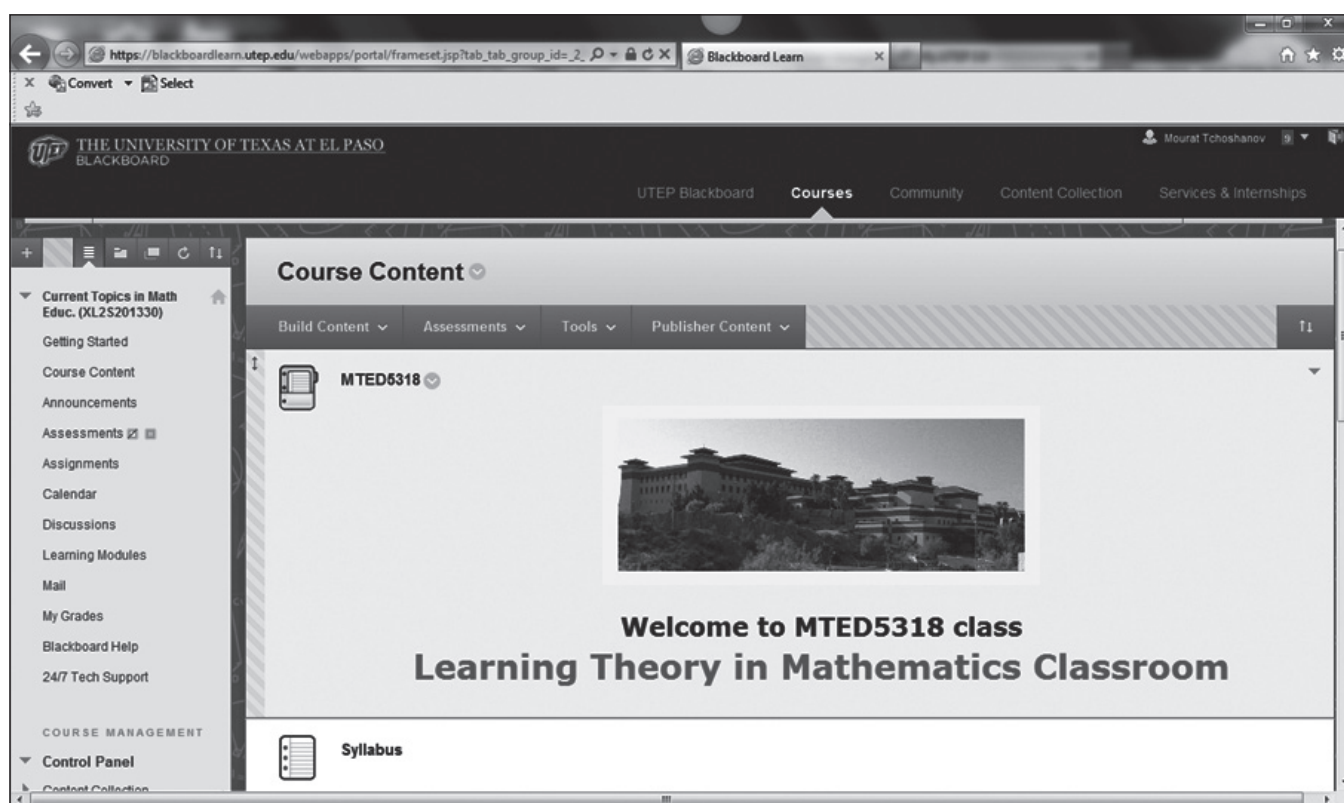


Fig. 1. Screenshot of the MTED5318 course homepage in the Blackboard learning system

book/spreadsheet with students' grades. The Users and Groups feature consists of the list of students enrolled in the course and enables the designer to organize students into groups. The Customization helps the designer to manage properties such as course availability, tool availability, and course appearance. The Packages and Utilities are used to import, export, and archive the course. The "Help" feature provides access to the Blackboard Learn Guide and On Demand Learning Center. The Course Content includes the following tools: Build Content, Assessments, Tools, and Publisher. The Build Content allows the designer develop the content of the course through uploading files, folders, posting syllabus, lesson plans, modules, and making links to external resources such as NBC Learn, for example. Assessments tool is used to create tests, surveys, assignments, etc. The Tools include discussion boards, blogs, wiki, etc. The "Publisher" provides links to the "Textbook publisher" and its additional resources such as "MyLab" and others. All the tools used in the Blackboard Learn could be categorized into two main groups: (1) interactive tools and (2) evaluation tools. The Interactive Tools include announcements (e. g., notifying students about course events, assignment clarifications, and schedule changes), blogs (e. g., an online journal or a diary), calendar (e. g., important events and dates in the course), collaboration (a synchronous communication tool including a virtual classroom and a chat-room), contacts (instructor's contact information), discussion board (an asynchronous communication tool for creating forums), glossary (e. g., a list of important course terms and definitions), groups (e. g., creating and managing groups), journals (e. g., similar to

a discussion board with a selective access to view journal entries), messages (e. g., similar to email), roster (the list of students enrolled in the class), email (sending email to students enrolled in the course), tasks (e. g., assigning as well as defining priority and tracking task status), wikis (allows students to collaborate on writing and editing course assignments). The "Evaluation Tools" group consists of course reports (e. g., information about students' activity and content usage), an early warning system (sending email to students when the due date, test score, or other criteria and requirements are not met), full grade center (a grade book with main course assignments and tests), needs grading (e. g., items pending for grading), performance dashboard (an up-to-date report on students' activity and performance), pools (e. g., a repository for test, quiz, survey questions), rubrics (e. g., creating a qualitative assessment criteria), safe-assign/turn-it-in assignments (e. g., self-checking for plagiarism). The key for the evaluation tools is the grade center which resembles a spreadsheet and is designed as a dynamic and interactive tool allowing the instructor to record data, calculate grades, and monitor the student progress. It also permits to generate reports on student performance. The instructor can customize views and create grading schemas including grading periods, categories, and columns to present and gather the desired information.

While designing an online course, the author uses the *didactical engineering approach* which was discussed in Part 1. It includes three major stages: analysis, design, and construction of teaching products in order to create an effective learning environment for distance learning. Let us consider

each stage in engineering of the MTED5318 course mentioned above.

The Analysis Stage. At this stage, the designer builds the foundation for the course through the study and analysis of standards, teacher competences, place and role of the course in the program, course description, texts and materials relevant to the topic of the course, digital media and ICT resources applicable to the course goals, teacher misconceptions, etc. The designer also selects the required textbook and readings materials as well as defines learning objectives at the analysis stage. The MTED 5318 is a semester-long graduate level topic course. It is aimed to “develop competencies necessary to deal effectively with mathematics instruction; includes curriculum, concepts, teaching strategies, and skills necessary to integrate content and teaching strategies”. The author selected the topic of “Learning theory in mathematics classroom” for this course and defined the following learning objectives. Upon completion of this course students should be able to:

- 1) know and understand the guiding principles of learning mathematics in the classroom;
- 2) apply the guiding principles in the mathematics classroom in order to develop students’ conceptual understanding and procedural fluency;
- 3) analyze and reflect upon implementation of the guiding principles in the middle school mathematics classroom;
- 4) evaluate effectiveness of learning in the mathematics classroom using selected ICT resources.

Through the extensive and careful analysis of available resources and materials relevant to the topic and learning objectives of the course, the author identified the following required texts for the course: 1) National Research Council (2005). How students learn mathematics in the classroom. M. Suzanne Donovan & John D. Bransford, Eds. Washington, DC: The National Academies Press (available on-line at: <http://books.nap.edu/catalog/10126.html>) [1]; 2) Boaler, J., & Humphreys, C. (2005). Connecting Mathematical Ideas: Middle school video cases to support teaching and learning. Portsmouth, NH: Heinemann [2].

The Design Stage. This stage focuses on the development of student learning pathway based on the learning objectives defined at the analysis stage. At

the design stage, the instructor is primarily concerned with the connection between the learning objectives, the course content, and the assessment of learning outcomes. In order to achieve the seamless connection, the instructor carefully designs and selects the major course activities, assignments and course deliverables. The assessment of learning outcomes in connection with the learning activities and assessment is shown in Table 1.

The Construction Stage. This stage is built on the design stage and aims at the selection and development of particular teaching products including but not limited to syllabus, modules, lessons, assignments, ICT resources, etc. It also aims at creating an effective online learning environment. The syllabus is the key document defining the course objectives, its content, requirements, and assessment. Structurally the syllabus may include the following components: title and description of the course; contact information about the developer/instructor of the course, including virtual office hours; learning objectives; connection between the objectives of the course, its content and assessment; textbooks and reading materials used in the course; schedule of classes and activities; list of course assignments; grading scale, rubrics, class participation requirements; software requirements; professionalism and academic integrity statements. The course content for the MTED5318 includes eight problem solving activities aligned with reflections on eight video cases of the middle school mathematics classroom, five chapters from the required text on “How Student Learn” with corresponding chapter tests, analysis and reflection on five selected ICT resources, four lesson plans for selected activities with classroom teaching and videotaping, a collection of student work, and participation in class discussions. There is a mixture of individual and group activities in the course. Problem solving as well as lesson plan design, teaching, and classroom videotaping are group activities whereas reflections, chapter tests and participation in discussions are individual activities.

At the construction stage, the designer uploads the course content into the LMS and selects the main interactive and evaluations tools to support and monitor student learning over the course duration. The author usually uploads the course materials two weeks prior to the beginning of the class so the students have

Table 1

Connecting learning objectives, learning activities, and learning outcomes

Learning Outcome	Achieved by	Measured by
To know and understand the guiding principles of learning mathematics in the classroom	Readings and reflections Participation in discussions	Concept Test Participation Checklist
To apply the guiding principles in the mathematics classroom in order to develop students’ conceptual understanding and procedural fluency	Applying activities in the classroom Participation in discussions	Lesson Plan and Video of Lesson Participation Checklist
To analyze and reflect upon implementation of the guiding principles in the middle school mathematics classroom	Reflections on video cases Participation in discussions	Written Reflection Participation Checklist
To evaluate the effectiveness of learning in mathematics classroom using selected ICT resources	Reflections on ICT enhanced activities Participation in discussions	Written Reflection Participation Checklist

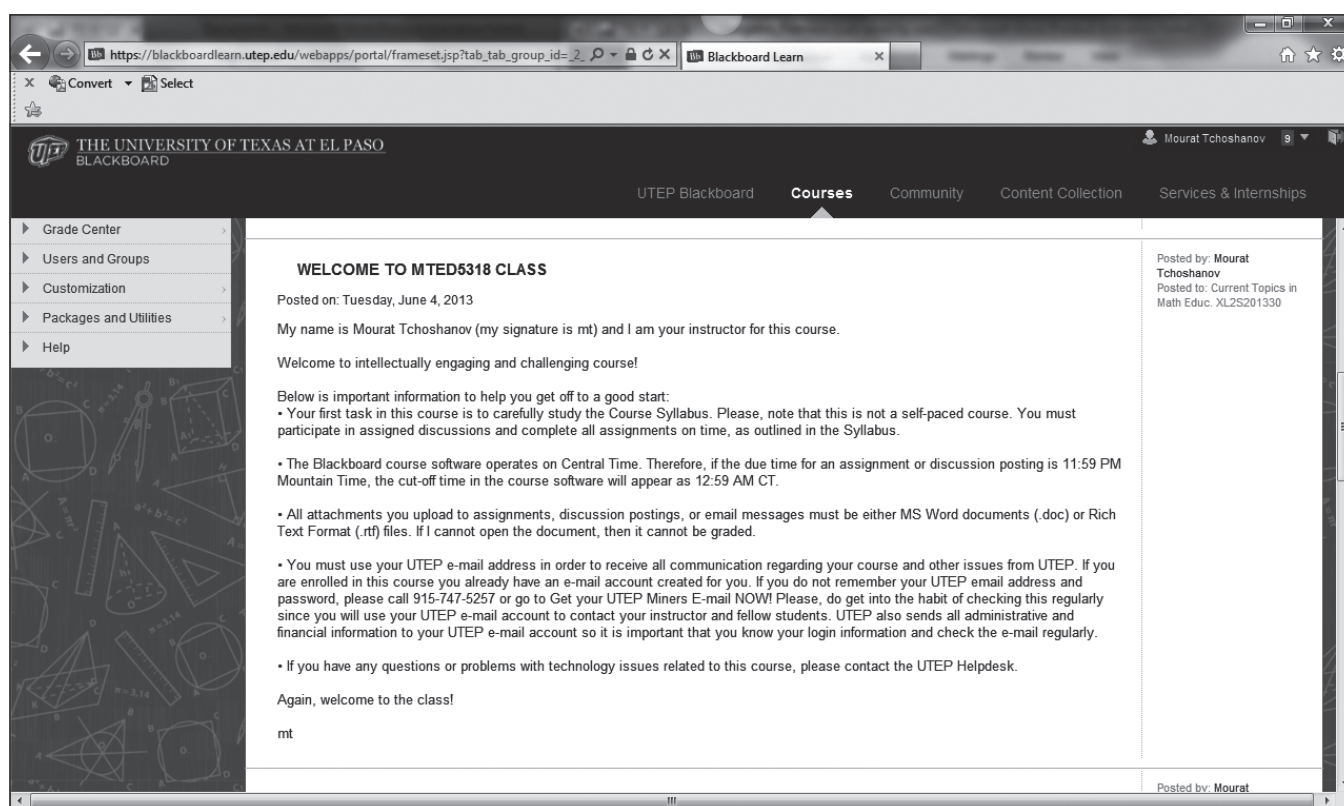


Fig. 2. Screenshot of the “Getting Started” message for the MTED5318 course

an access to view the syllabus and major requirements of the course. The students may also need an extra time to order the required texts for the course. The “Getting started” feature at the course menu is an important step in the beginning of the course where the instructor introduces himself/herself and sends a welcome message and an invitation to the course. The “getting started” message may also outline the key information for students to help them get off to a good start such as friendly suggestions, communication and software requirements, support system, etc. (Figure 2).

One of the central course assignments is problem solving, analysis, reflection, lesson planning and teaching based on the selected video cases of the middle school mathematics classroom. This assignment is a connected set of activities that addresses the learning objectives of the course and outlines the student learning pathway. It consists of the following steps:

- 1) pre-video problem solving activity;
- 2) during-video analysis of the didactical situations occurring in the video;
- 3) post-video reflection;
- 4) post-video discussion;
- 5) video-based lesson plan development;
- 6) pre-teaching conference;
- 7) teaching and videotaping the lesson;
- 8) reviewing and analyzing the classroom video.

The first step is to involve students in solving the problem that later they will watch in the video. Let us consider the “Border problem” from the first video episode as an example. The instructor divides the class into small groups to work on the following activity:

Problem 1: Using the 10 by 10 grid (Figure 3), figure out *without writing and without counting one by*

one, how many unit squares are in the colored border of the grid? Explain your method.

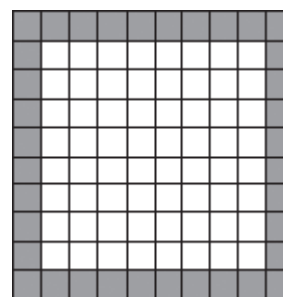


Fig. 3. Border problem (version 1)

Problem 2: How many unit squares are in the colored border of the grid below (Figure 4)? Explain your method.

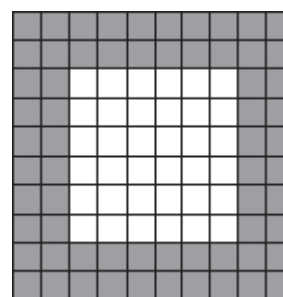


Fig. 4. Border problem (version 2)

The groups post their solutions and explanations on the discussion board. The whole class has a chance

to comment on the posted group solutions before the next online session where the instructor provides an access to the video case (Figure 5).

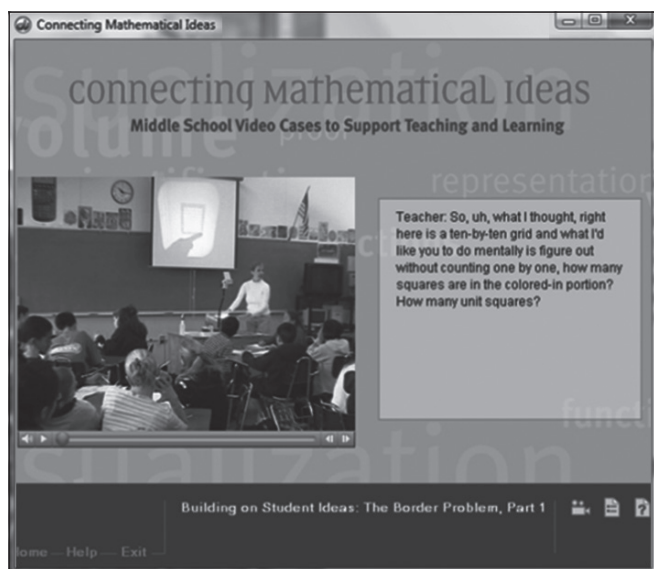


Fig. 5. Video case based problem solving activity

“During-video” activity includes an element of *gamification*. The game-based learning activity designed for this assignment is called “*Didactical Chess*”. The objective of the game is to watch the video case until the pause point purposefully selected by the instructor, analyze the situation, come up with the most effective didactical move, and justify why the selected move is the most effective with regard to student learning. Below are the steps of the game. First, the designer/instructor carefully selects the didactical situation(s) in the video that include teachable moments, such as student ways of problem solving, student misconceptions, student questions, etc. The designer includes the pause point in the video track. The students watch the video until that very point and during the pause they individually work on the “Engineering of a didactical move” chart which includes the following segments:

1. Analyzing the situation:
 - a) analyze the content;
 - b) analyze the teacher action(s);
 - c) analyze the student action(s);
 - d) analyze the classroom environment.
2. Designing possible didactical moves:
 - a) define the didactical task;
 - b) identify the main factors impacting the potential move(s);
 - c) list possible didactical moves.
3. Selecting the move and constructing the next didactical situation:
 - a) select the most effective didactical move;
 - b) justify why it is effective;
 - c) construct a similar didactical situation.

The main purpose is to come up with the next most effective move, if they were teachers in the video. Students can rewind the video back but they cannot continue watching the video until they submit the response. The most intriguing part for the students after completing the response is to watch the teacher

action in the video case. It usually happens that few students might come up exactly with the same move as in the video. The designer/instructor usually selects one didactical situation per video case. The “Didactical Chess” activity involves teachers in zooming into details and dissecting the “molecular” didactical situations into “teaching atoms”. Good teaching is about being able to conduct microscopic analysis of teaching craft and, based on this analysis, to understand how to effectively engineer student learning. After all, ‘the devil is in the details’. The post-video activity includes an individual student reflection on the entire video case. The sequence in the video lesson included the following events (adapted from Boaler & Humphreys, 2005): the teacher collected “wrong” answers to the “Border Problem” and asked students’ reaction and thinking about the incorrect answers; the teacher collected different methods for thinking about the correct solution; the teacher gave a method from the previous day’s class and asked students to make sense of it geometrically; the teacher initiated the discussion of the similarities and differences between methods; the teacher posed a question about shrinking the square to a 6-by-6 grid and there was some discussion of the proposed student answers. The reflection was supported by the following guiding questions subdivided into four main areas: (1) the activity, (2) the teacher; (3) the students; (4) the classroom environment [2].

The Activity section includes the following questions for reflection: What were the mathematical tasks of the lesson? How did they follow from the main activity? What do you think about each of the events in the lesson? What do you think about the progression of the events? What mathematics means did each of them suggest? What were the decision points in the lesson that had changed the flow of the activity and when did they occur? Were there any didactical situations in the lesson you would have approached differently? What mathematical content and mathematical process did the lesson address? Where could this lesson go from here? What could students work on during in the next lesson?

The Teacher section of the reflection consists of the following questions: How did the teacher respond to student’s different methods? How did the teacher capitalize upon student’s diverse way of thinking? How did the teacher gather information from the students? What kinds of information did she gather? What would you have done differently if you were the teacher? At which didactical situations would you have made different decisions and why?

The Students section includes the following questions: What did students learn in this lesson? Do you think it was different for different students? How? Why? What were the various roles students played in the classroom? What different things were the students required doing? What questions did students ask? Which students were contributing or not contributing to the discussion?

Finally, *the Environment* area of the reflection includes the following set of questions: What classroom norms did you see in this class? What do you think the teacher had done to set up these norms? How was the classroom arranged? What materials were used

and which role did they play? What in the classroom environment made the mathematics more visible?

After the students submit individual reflections, the instructor invites them to the post-video discussion. An example of the invitation to the discussion on video cases consisting of the “Border Problem” is presented below.

“Dear All,

It took me a little longer to read first two reflections. At the same time, I have had enough time to think how to respond to the issues that were challenging to the most of you. Based on your reflections, I feel that many of you enjoyed watching Cathy’s teaching. I did too. Particularly, I value her way of engaging students in learning and understanding of challenging topics in algebra such as pattern generalization, concept of variable and notion of proof. The first comment I would like to make is don’t shy away from digging deeper in the content. After all, this is a class on learning mathematics.

Now, let me share my observations on some of the important content-specific issues related to video cases 1 and 2. The ideas of a pattern generalization (video case 1) and a variable (video case 2) are key concepts. In video case 2, Cathy nicely pushes students to use letters in order to come with an algebraic expression for Joe’s case. I wish Cathy would make a very important distinction in the role letters play in algebraic representations. Letters could play a dual role: for example, in an equation $4x - 4 = 36$, x is unknown, in a function $y = 4x - 4$, x is variable. The case when x is variable takes care of students’ confusion on the question “What is staying the same and what is changing?” “4” is staying the same as a number of sides for any square as well as “-4” stays the same because you always have to take off four overlapping unit squares in the corners, and x is changing (it could be 10 for the case of 10x10 square, it could be 6 for the case of 6x6 square, it could be 100 for the case of 100x100, and so on). Understanding what is a variable, also addresses the question “How might you explain to students when another variable is needed?” In one of the episodes, Pam suggested to use two variables s and $n=s-2$ for the side lengths. How would you address this issue?

*At the same time, in the expression $y = 4x - 4$ we, indeed, have two variables: an independent variable x — the number of unit squares on one side of a given square, and a dependent variable y — the total number of unit squares on the border of a given square. So, if $x=10$, then $y=36$. If $x=6$, then $y=20$, and so on. If so, do we need two independent variables in this case!? Does this make sense to you? If your answer is “yes”, explain why? If “not”, share your concerns, please. mt**

Through the invitation, the instructor encourages the students to dig deeper into the important content-specific issues addressed in the video case. Unfortunately, some of the middle school teachers have a tendency to use a general and descriptive way of reflecting on video cases. Some of them shy away from the content. Instructor’s role is to engage

the students into the content-focused discourse and sustain the focus throughout the discussion. After the individual participation in the discussion, the students work in groups on developing the lesson plan based on the same video case. When the draft of the lesson plan is ready, the group submits it to the instructor and requests a virtual office hour to conduct a pre-teaching conference. The instructor holds a synchronous conference with the group via chat room or Skype and provides a feedback on the lesson plan developed by the group. The second synchronous post-teaching conference is conducted after the group has taught the lesson and submitted the videotape to the instructor. The post-teaching conference concludes the engineering of teacher learning cycle: teacher learning — lesson planning — teaching practice — student learning (Figure 6).

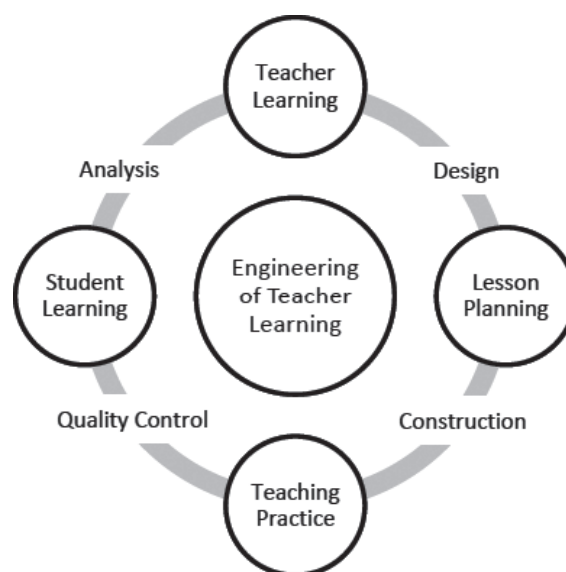


Fig. 6. Engineering of teacher learning cycle

Another activity used in the online MTED5318 class is an analysis and reflection on selected digital interactive ICT resources. For example, in order to achieve the course objective — “To evaluate effectiveness of learning in mathematics classroom using selected ICT resources” — students are assigned the task: “Explore the e-example, “Understanding Distance, Speed, and Time Relationships Using Simulation Software” (Figure 7: <http://standards.nctm.org/document/eexamples/chap5/5.2/index.htm>). Set up several trials using the simulation applet. You may try out this activity in your own classroom. Evaluate the effectiveness of this activity in promoting student learning. Reflect on the following question: what big ideas about functions and representing change over time students learn while working on this activity?”

Throughout the course activities, the instructor continuously encourages students to focus on the content and develop their pedagogical knowledge and skills. Another way to emphasize the importance of content-specificity is to construct and provide rubrics for the students’ reflection and participation in the discussion. An example of such a rubric is presented in Table 2.

* mt — course instructor’s signature (abbreviation of the author’s initials).

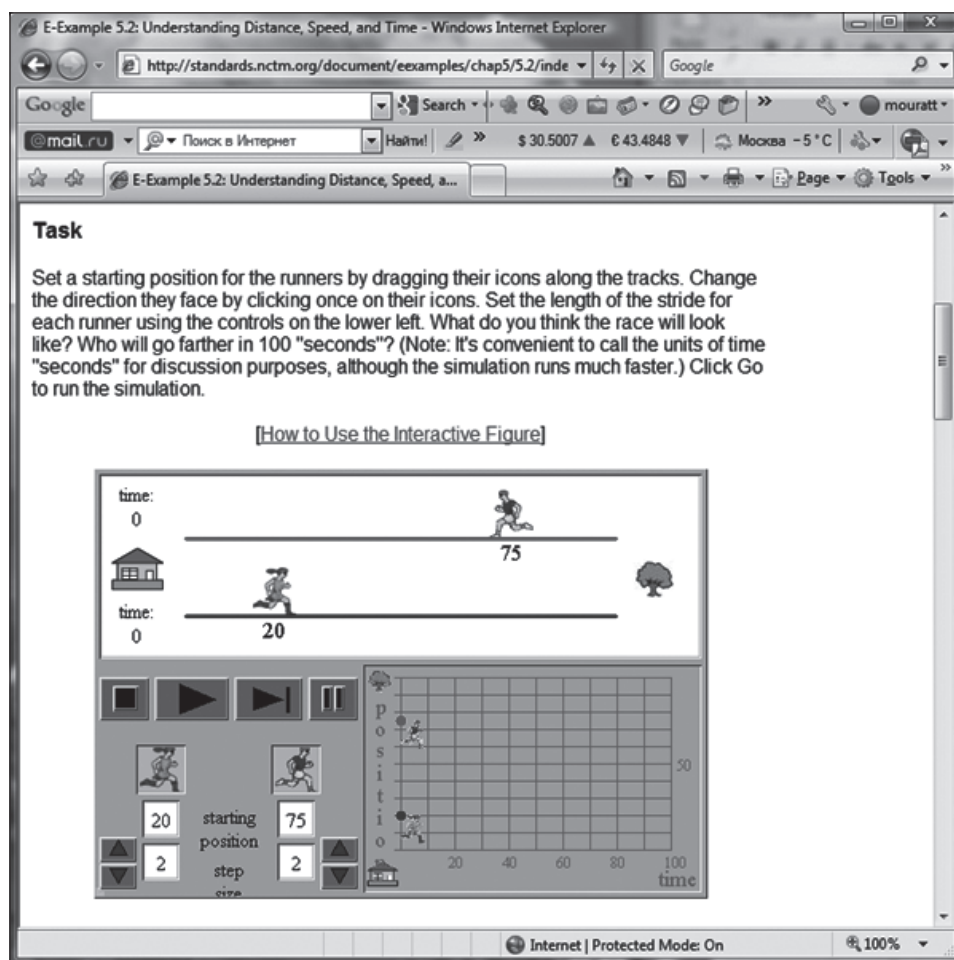


Fig. 7. Screenshot of a digital interactive learning resource

Table 2

An example of the rubrics for assessment of students' reflections and discussions

Quality	High 4.0 Points	Good 3.0 Points	Satisfactory 2.0 Points	Poor 1.0 Point
Completeness	Responds to all questions	Responds to most questions	Responds to few questions	Responds to one question or does not respond a single question
Clarity and Details	The main idea stands out and is supported by detailed and content-specific information	The main idea is clear but the supporting information is too general	The main idea is somewhat clear but there is a need for more supporting information	The main idea is not clear. There is a seemingly random collection of information
Accuracy	All supportive facts are reported accurately	Almost all supportive facts are reported accurately	Few supportive facts are reported accurately	No facts are reported or most are inaccurately reported
Resources	All resources used for quotes and facts are credible and cited correctly using APA format	Most resources used for quotes and facts are credible and cited correctly using APA format	Few resources used for quotes and facts are credible and cited incorrectly	The resources used for quotes and facts are less than credible (suspect) and cited incorrectly
Grammar	No errors in grammar or spelling distracting reader's attention	One or two errors in grammar or spelling that distract the reader from the content	Three or four errors in grammar or spelling that distract the reader from the content	More than 4 errors in grammar or spelling that distract reader's attention from the content

At the end of the semester, the students develop an e-folio, which includes all the major assignments for the course including problem solving, reflections, chapter tests, lesson plans, classroom videos as well as students' contribution to the class discussions.

In Lieu of Results

The students' course evaluations conducted at the end of the semester reflect the level of intellectual challenge, as well as benefits the course offers for both pre and in-service teachers enrolled in the class. Below are the samples of students' evaluations.

"This course has been a great experience for me. It was challenging and thought provoking. The assignments have been challenging too and have addressed mathematical topics that will contribute to enhancing my teaching perspective and experience. The course was well facilitated. The teacher provided ample time and instruction for the assignments to be understood and completed. I can definitely say that I have enjoyed being the part of this online course."

"This course was extremely rigorous! It is absolutely the best course I have taken at the UTEP and should be a mandatory course for anyone pursuing a degree in teaching. I had learned far more than I expected to learn, and left with many ideas for things I could do to help my future students understand math. Other courses I have had at UTEP have been very theoretical or have asked me (someone with very limited experiences in the classroom) to come up with lesson plans or discipline plans (which I really didn't know anything about — so the lesson plans I came up with were not based in reality). This course GAVE me the lesson ideas, showed me the ways of teaching, and then asked me to evaluate which ones I thought would be most effective or least effective. Instead of having me create lessons out of thin air with no past experience to build on, I had the chance to observe great lessons — I now have some ideas to emulate. I LOVE this model. It's amazingly helpful. I will gladly take any other courses Dr. T is teaching (but I'll be sure I'm not too busy because this class was TOUGH and took much more time than I expected). However I learned a great deal for my investment in time and money, and I really feel that this course was a good investment."*

*"I really do want to give high remarks for this professor for the selection in course textbooks and assignments. Out of all the ATCP** courses I have taken, I feel this has been the most beneficial, effective, and the most that I have learned. The professor was very good in responding and giving good discussion questions and his own discussion remarks. Despite being an online course, the instructor was very efficient in answering e-mails and assisting students with technical problems."*

Synthesizing the multiyear engagement in designing and teaching online courses, the author concludes that it is a challenging yet a rewarding experience that

requires seamless integration of content, didactical and engineering knowledge and skills to create an effective learning environment in distance education. This new type of knowledge the author calls CODE = *content-oriented didactical engineering* knowledge. The author believes that this type of knowledge emerges as a critically important code to unlock challenges of designing effective learning environments and improving teacher competence in the digital age [3].

Conclusion

In today's world, current revolutionary changes are associated with the intensive use of digital technologies in many spheres of human life, which democratize knowledge and access to open education. The ICT is increasingly implemented in the daily lives of individuals and the society. We are witnessing the formation of a new phenomenon — a global virtual learning community, which today includes more than one billion users. And the numbers continue to grow. Along with this, the market of online educational services is steadily growing. For example, in the Department of Teacher Education at the University of Texas at El Paso (USA) about 50 % of graduate courses are conducted in an online format. With the purpose of expanding online services, the leading universities create MOOC consortiums (e. g. Coursera, Udacity, edX, etc.) to initiate special programs for supporting the design and delivery of online courses, as well as the development of new tools for online learning systems. This creates a domino effect: along with the transfer of many university disciplines, including teacher education courses to the online format, there is a need to revisit the training of school teachers. Instead of the traditional teacher training, the focus is shifting toward a new type of training for teachers who can work in the digital age, with high demands on teachers' knowledge and ability to engineer an effective online learning. Moreover, in the digital era a teacher is not just an online tutor, s/he becomes an analyst and manager of informational resources, a designer and a constructor of courses, modules, and lesson fragments using interactive multimedia tools.

In connection with the emerging changes in the role of teachers in the digital age an important question arises: what kind of teacher is needed in the digital age? In order to meet the demands of the new era, a teacher in a traditional sense (e. g., someone who teaches) should be replaced by a teacher-engineer (e. g., someone who engineers student learning). This shift comprises integration of teacher knowledge of content, engineering, and didactics. At the same time, the integration implies reconceptualization of the key role of a *teacher-engineer* in the digital age: traditional teaching transforms into a *research-based engineering of student learning*. This transformation requires a teacher-engineer to understand the teaching theory and learning sciences in order to effectively design the learning objectives, digital content, and assessment, and to connect them.

The 'engineering of learning' paradigm places a critical emphasis on the development of teachers' engineering design thinking. The development of teacher-engineer's design thinking is a complex process

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** Alternative Teacher Certification Program, which is a part of the Teacher Education program at the University of Texas at El Paso.

based on the advancements of the learning sciences. It involves the following key competences:

- 1) the design of learning objectives: to create outcome-based, technology-enhanced learning environments that enable students to set their own learning objectives, monitor and assess their learning progress;
- 2) the engineering of content: to develop interactive content and relevant learning experiences through the selection and design of tasks, problems, projects, and activities that incorporate digital tools and ICT resources to promote student learning and creativity;
- 3) the design of assessment: to select and develop authentic assessments aligned with the learning objectives and content, and to use assessment data to improve teaching and promote student learning.

In order to respond to the challenges of the digital age, didactics itself needs to be re-conceptualized. This re-conceptualization has a clearly defined vector. Modern didactics is moving towards strengthening its “engineering” functions — didactical engineering. We call this trend *e-Didactics* and define it as ICT-integrated didactics with its major focus on *engineering of learning*. Didactical engineering is a relatively new approach in education. It focuses on the “precise” design of the learning process, which can later be reproduced in other “point” of time and space under the predetermined conditions. e-Didactics aims to use

scientific methods and promotes the formation of the teachers’ design thinking. e-Didactics also fosters the development of teachers’ analytic reasoning focused on the implementation of macro and micro analysis of didactical systems, processes and situations. Accordingly, e-Didactics has its own subject domain that is characterized by the following main parameters: analysis, design and construction of outcome-oriented teaching products (e. g., learning technologies); application of a scientific method and design thinking into the analysis of didactical systems, processes and situations in order to create effective learning environments.

The development of didactics in the direction of the e-Didactics and didactical engineering offers new opportunities for further understanding of learning and teaching in the digital age and creating effective learning environments in an emerging global learning community.

References

1. National Research Council. How students learn mathematics in the classroom. (M. S. Donovan, J. D. Bransford, Eds.). Washington, DC: The National Academies Press, 2005. Available at: <http://books.nap.edu/catalog/10126.html>
2. Boaler J., Humphreys C. Connecting Mathematical Ideas: Middle school video cases to support teaching and learning. Portsmouth, NH: Heinemann, 2005.
3. Tchoshanov M. Engineering of learning technologies. Moscow: Binom, 2011. 239 p. (In Russian.)

ДИДАКТИКА ЦИФРОВОЙ ЭПОХИ: ОТ ПРЕПОДАВАНИЯ К ИНЖЕНЕРИИ УЧЕНИЯ ЧАСТЬ 2

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Аннотация

Цифровая эпоха требует пересмотра традиционного преподавания и учения. Быстро растущие технологические инновации в образовании обуславливают смену парадигмы от традиционного преподавания к инженерии учения. Таким образом, основное внимание в статье уделено разработке и внедрению эффективных учебных сред на основе использования информационных и коммуникационных технологий в различных форматах: очное обучение, смешанное и дистанционное. Инженерия учения требует нового понимания и переосмысления традиционной дидактики в направлении е-дидактики (электронной дидактики), чтобы эффективно проектировать и умело согласовывать цели учения, его содержание и систему оценивания в цифровую эпоху.

Ключевые слова: дидактическая инженерия, цифровая эпоха, учитель-инженер, эффективная учебная среда.

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