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# Performance support system for thermal management engineers workplace learning

**Nadezhda M. Kafadarova, Silviya Stoyanova-Petrova, Anna V. Andonova**

*In this paper, we describe our approach to the implementation of a DIPSEIL system to provide performance support learning and training for thermal management engineers on their workplace. The real demands of the newly emerging labor market, where human resources development becomes a priority of a new order, have inspired the quick development of a Partnership between Higher Education and Industry. The Partnership increases demand for education and training and individual motivation to learn; improves efficiency through better guidance and intermediating, by providing new methods, programs and resources, and by using ICT.* ***The needs of electronic engineers dealing with the thermal management of electronic systems to acquire additional knowledge in their workplace*** *lead to development, implementation and on-going evaluation of Internet-based courses. We find that workplace Internet-based learning should align individual and organizational learning needs and connect learning and work performance. To achieve this, a performance-oriented approach is proposed in this study. Key performance indicators are utilized to clarify organizational goals, make sense of work context and requests on work performance, and accordingly help employees set up rational learning objectives and enhance their learning process.*

***Проектно базирана система за обучение на инженери на работното им място (Надежда Кафадарова, Силвия Стоянова-Петрова, Анна Андонова).*** *В тази статия описваме нашия подход при приложението на системата DIPSEIL за осигуряване на проектно базирано обучение на работното място за инженери, занимаващи се с топлинно управление на електронни системи. Реалните потребности на нововъзникващите пазари на труда, където развитието на човешките ресурси става приоритет с първостепенно значение, са вдъхновили бързото развитие на партньорството между висшето образование и индустрията. Това партньорство увеличава необходимостта от образование и индивидуална мотивация за обучение, подобрява ефективността чрез подобро ръководство и посредничество, чрез предоставяне на нови методи, програми и ресурси и чрез използване на информационни и комуникационни технологии.* ***Необходимостта на електронните инженери, занимаващи се с топлинно управление на електронни системи, да придобиват допълнителни знания на работното им място,*** *води до развитие, изпълнение и по-нататъчно оценяване на интернет-базираните курсове. Ние забелязваме, че Интернет-базираното обучение на работното място би следвало да хармонизира индивидуалните и организационните нужди от обучение и да свърже обучението с изпълнението на работата. За постигане на тези цели в настоящото изследване се предлага използването на проектно-ориентирания подход. Ключовите показатели за изпълнението на целите се използват за изясняване на организационните цели, дават смисъл на работния контекст, както и искват изпълнение на работата, и съответно помагат на служителите да създадат рационални учебни цели и повишат ефективността на учебния процес.*

## Introduction

In adult education, performance support learning, in contrast to formal curriculum-driven, instructor-led settings such as colleges and universities, suggests greater flexibility or self-directedness for learners. Informal learning in the context of the workplace is the process of learning while on the job. Informal workplace learning encompasses activities that are originated by employees that broaden or enhance their professional knowledge and skills. Valuable performance support workplace learning is taking place with regularity and great magnitude. Resulting in constructive information and processes and perspectives, informal workplace learning must be systemized to realize its value in enhancing or supporting organization wide performance.

A 'Performance Support System' or PSS refers to any system that improves worker productivity by providing on-the-job access to integrated information, advice and learning experiences.

*The four components of a good PSS are:*

- Advisory Component - The advisory component of the PSS usually consists of a job-aid in an electronic form. The learners can use the advice without having a deep understanding of the task. If they need to understand something in greater detail, the learners can access the other components of the performance support system. The advisory component is meant to provide help wherever and whenever the user requires it;
- Information Component - The information component of the PSS consists of the tools that the learners can use to access information in the form of procedures, regulations, company policies, specifications, images, graphics, videos and podcasts. The information component is meant to provide all the information the users require to do their job;
- Training Component - The training component of the PSS helps the user access training material on demand;
- User Interface Component - The user interface is the most important aspect of the PSS. It seamlessly integrates all the components of the performance support system. The user interface enables the learner to navigate from component to component within the PSS. It is absolutely essential that the interface is user-centric and presents a consistent look and feel for all the components in the PSS.

The challenge in supporting informal workplace learning is to develop content rapidly, make it highly accessible and integrate it into the workflow. The first step in meeting this challenge is recognizing that employees are a main source of creativity and organizational improvement. Designing, developing, and implementing performance support for informal learning produces a medium that enhances workplace performance.

A good performance support learning platform provides users with a internet based environment where they can access the training activities in the form of videos, podcasts, eLearning courses, quizzes and evaluation surveys and also enables them to use their mobile device to share knowledge with others (within or outside their team) in real-time.

**Principles and concepts of performance support learning system DIPSEIL**

In this paper we represent the implementation of our *performance support learning solution* – DIPSEIL (DIPSEIL is created acoording to the European Union Socretes Project) in the workplace learning of electronic engineers who are responsible for the thermal management of electronic systems (fig.1). DIPSEIL is equipped with a comprehensive set of features that make the management of learning for the workplace easy and effective [1], [2]. Its right mix of traditional and innovative features work towards giving an experience that truly surpasses place and time boundaries. DIPSEIL puts training and performance support where the actual work takes place; allows new skills or knowledge to be immediately applied; enables training when it is needed.

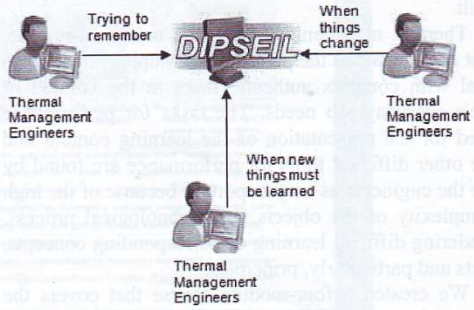


*Fig.1. Performance support learning solution – DIPSEIL*

The following items summarize some of the key principles and concepts of DIPSEIL to meet the needs of thermal management engineers to improve their knowledge or to fill some gaps in it:

- The focus is on learning needed to do specific tasks;
- Individualized self-paced learning takes less time than classroom instruction;
- Learning transfers to real work performance - it is tied to the work;
- Materials and resources are used systematically - job-related references and manuals; job aids; training/learning materials.

**Thermal Modeling and Characterization of Electronic Systems – course overview**

Over the last decade, design practices have progressed from basic analytical and semi-emperical calculations, applicable to simple systems, in tandem with extensive physical prototype characterization, to a high reliance on virtual prototyping using numerical predictive techniques. Their application, now widespread within electronics industry, has been enabled by increases in computational power, and contributed to significantly reduce both prototyping costs and development cycle times. The use of Computational Fluid Dynamics (CFD)–based methods that simultaneously solve the appropriate governing equations for the solid and fluid domains is the most realistic approach for the prediction for the conjugate heat transfer in electronic equipment.

Powerful 3D computational fluid dynamics (CFD) software that predicts airflow and heat transfer in and around electronic equipment, from components and boards up to complete systems is the commercially available FloTHERM®. FloTHERM enables engineers to create virtual models of electronic equipment, perform thermal analysis, and test design modifications quickly and easily before any physical prototypes are built.

Thermal management engineers need just-in-time, just enough and at the point of need support in order to deal with complex authentic tasks in the context of their everyday job needs. The tasks for performance used for the presentation of the learning content and the other different tools for performance are found by the the engineers as very important because of the high complexity of the objects and technological process, rendering difficult learning of corresponding concepts, facts and particularly, principles.

We created a four-module course that covers the application of numerical methods to electronic equipment thermal design, from component to system level. The name of the course is „Thermal Modeling and Characterization of Electronic Systems" [3], [4]. The course provides guidance on optimizing the application of CFD analysis to electronic system thermal design, from the selection of a cooling strategy, refinement of the thermal design by parametric analysis, to providing perspective on the use of temperature predictions as critical boundary conditions in electrical performance- and thermo-mechanical behavior analyses. The course covers the fundamentals of thermofluid measurements to characterize electronics thermal performance. Specific methods for characterizing important system elements, such as PCBs, micro-contact connections, power LEDs and LED devices are outlined [5].

The application of the techniques presented permit the thermofluid phenomena in a given application to be understood, guide the thermal design process, and ultimately permit product thermal performance to be qualified.

Practical case workplace studies dealing with the modeling and thermal characterization of electronic products are presented throughout the course, involving the analysis of system-, board- and component level heat transfer.

Each module consists of two to four tasks. The modules and the tasks are listed bellow:

- Module 1: Building and Solving a FloTHERM Project. It consists of four tasks – a) Basics of FloTHERM; b) Creating a new project; c) Adding grid; d) Solving the project in steady-state or transient mode.
- Module 2: Thermal management of 3D micro-contact connections. It consists of two tasks – a) Microcontacts of pin-ring type; b) Ball Grid Array Package.
- Module 3: Thermal management of PCB. It consists of four tasks – a) Calculation of the effective therma conductivity of PCBs; b) Influence of source size in the calculation of effective conductivity; c) Influence of layer placement in the cculation of effective conductivity; d) Influence of source location in the calculation of

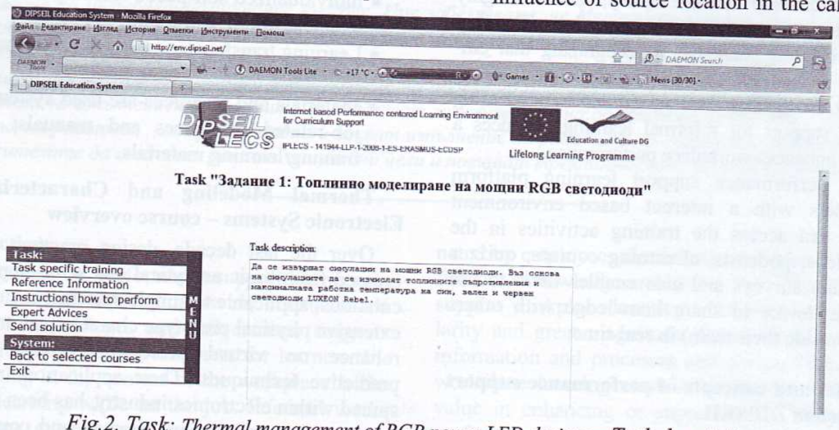


*Fig.2. Task: Thermal management of RGB power LED devices – Task description*

effective conductivity.

- Module 4: Thermal management of RGB power LED devices. It consists of four tasks – a) Calculation of the transition temperature and thermal resistance of LED and its comparison with the set of technical characteristics; b) Calculation of thermal resistance and maximum operating temperature of the blue, green and red LEDs LUXEON Rebel; c) Thermal modeling of power LED devices; d) Basic concepts for a choice of a radiator for LED devices cooling.

On fig.2 there is given the "Task description" of a task from Module 4.

Fig.3 shows the screen of the "Task specific training" for a task from Module 2. Fig 4 represents how the "Instructions how to perform" screen looks like.

On fig. 5 one can see other examples of "Reference Information" screens for different tasks.

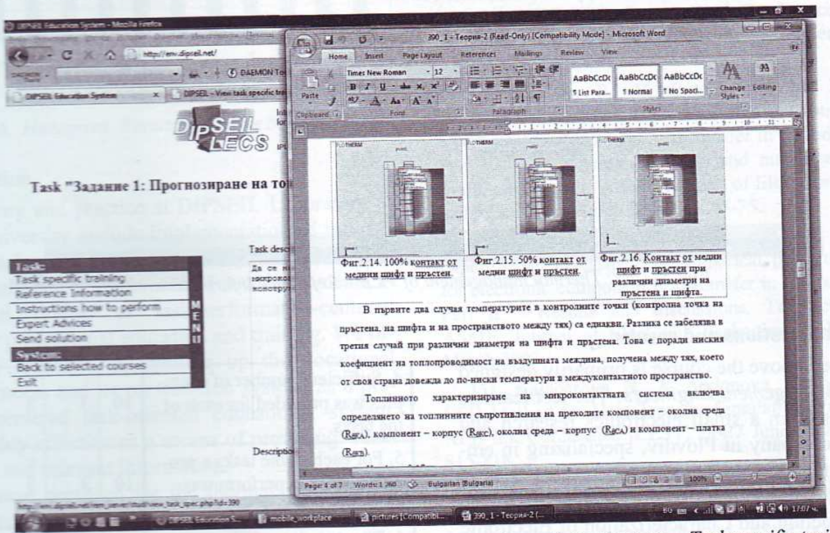


*Fig. 3. Task: Thermal management of 3D micro-contact connections of pin-ring type – Task specific training*

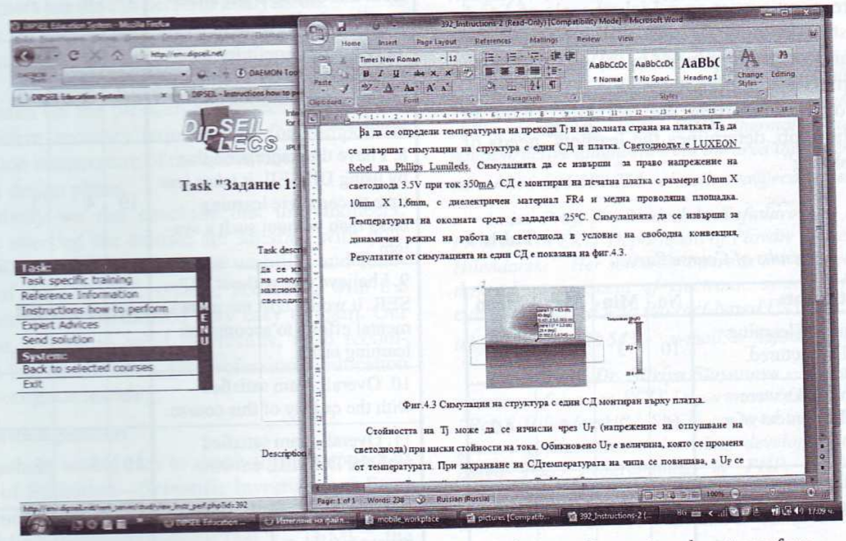


*Fig. 4. Task: Thermal management of RGB power LED devices - Instructions how to perform*

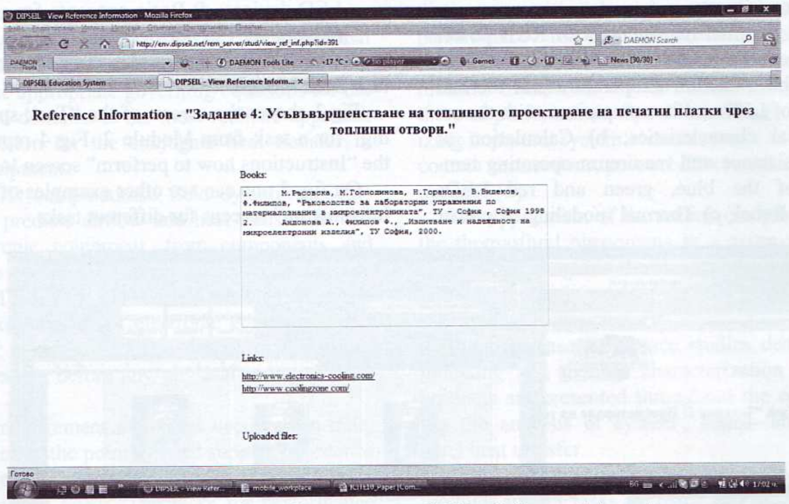


*Fig. 5. Task: Thermal management of PCB – Reference information*

## Evaluation questions and results

As described above the course is primarily designed for *Thermal Management Engineers*. The test learners are employees from a small electronics research and development company in Plovdiv, specializing in embedded communication systems.

To evaluate achievement of learning goals in the "Thermal Modeling and Characterization of Electronic Systems" course, we administered course questionnaires. The responses were on a Lickert scale of 1 to 5 where 1 = strongly disagree and 5 = strongly agree (Table 1). Ten workers responded to the survey.

The complexity of the knowledge and skills necessary to perform successfully the tasks they have as workers in their job, determines the learners' needs of "practical learning".

**Table 1**

*Results of Course Survey*

| Statements | No | Min | Max | Mean |
|---|---|---|---|---|
| 1. The sequence of learning tasks was well structured. | 10 | 3 | 5 | 4.3 |
| 2. The learning tasks were presented in the context of a job. | 10 | 3 | 5 | 4.2 |
| 3. Sufficient theoretical information was provided for each of the tasks. | 10 | 4 | 5 | 4.4 |
| 4. Sufficient number of examples was provided for each of the tasks. | 10 | 3 | 5 | 4.0 |
| 5. For each of the tasks a procedure how to perform was provided. | 10 | 3 | 5 | 4.2 |
| 6. The main benefit for me from this course is the understanding the learning content. | 10 | 3 | 5 | 3.9 |
| 7. The main benefit for me from this course is the ability to solve real-life authentic problems. | 10 | 4 | 5 | 4.4 |
| 8. I have the impression that by using DIPSEIL it takes less time to complete learning tasks than without such a system. | 10 | 4 | 5 | 4.4 |
| 9. I believe that without DIPSEIL it would cost me more mental efforts to accomplish learning tasks. | 10 | 3 | 5 | 4.5 |
| 10. Overall, I am satisfied with the quality of this course. | 10 | 3 | 5 | 4.3 |
| 11. Overall, I am satisfied with the DIPSEIL environment. | 10 | 3 | 5 | 4.3 |
| 12. I would recommend this course to others. | 10 | 4 | 5 | 4.6 |

In the histogram (Fig.6) we can see, quickly, the high evaluation given by the workers to the course.

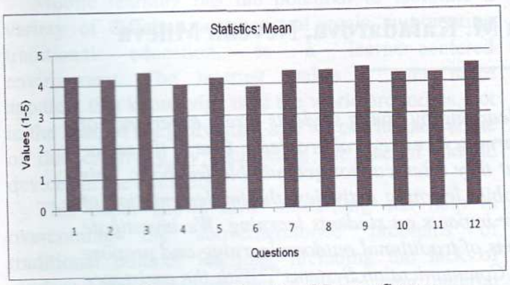


*Fig.6. Histogram. Results of Course Survey*

**Conclusion**

The theory and practice at DIPSEIL Laboratory at Plovdiv University include implementation of innovative approaches for Internet-based performance-centered learning and development of new instruments in instructional design of task-performance-centered courses for professional education and training. We offer a new approach of thinking up the vocational learning process and its presentation system, as a performance-centered task-oriented educational system. This is highly effective as a means of providing workers, timely and relevant information.

The course provided for the thermal management engineers covers full CFD analysis in the thermal design process of electronic equipment. By the end of the course learners are able to perform analysis on:

- Early to intermediate thermal design phase, including selection of cooling strategy and refinement of thermal design by parametric analysis; emphasis on the productivity of design analysis; predictive accuracy requirements for component junction temperature of measurement.
- Final design phase.

Definitively we can conclude that the engineers, who have attended the course, are satisfied with how the DIPSEIL platform works. The usability and functionality of the DIPSEIL system, according with the workers answer, is considered very easy to learn. Our conclusion, having in mind the results, is to recommend the use of DIPSEIL for professional education and for workplace learning.


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**REFERENCES**


[1] Mileva, N., D.Tokmakov, S. Stoyanova, R. Messnarz, D. Ekert. Integration of ipss_ee data-base with capability adviser in the framework of training/learning partnership between industry and higher education, International Conference on multimedia & ICT's in Education, June 7-10th 2005, SPAIN, Vol.3, 951-956.

[2] Mileva, N., D. Tokmakov, M. Milev, S. Stoyanova. Developing and Learning with Distributed Internet-based Performance Support Environment for Individualized Learning - DIPSEIL. International Conference ICL 2007 (Interactive Computer Aided Learning), September 26-28, 2007, Villach, Austria.

[3] Rodgers, P., V. Eveloy and M. Davies. An experimental assessment of numerical predictive accuracy for electronic component heat transfer in forced convection: Part I – Experimental methods and numerical modeling. Transactions of the ASME, Journal of Electronic Packaging, Vol.125, No. 1, March 2003, pp. 67-75.

[4] Rodgers, P., V. Eveloy and M. Davies. An experimental assessment of numerical predictive accuracy for electronic component heat transfer in forced convection: Part II – Results and discussions. Transactions of the ASME, Journal of Electronic Packaging, Vol.125, No. 1, March 2003.

[5] Kafadarova, N., A. Andonova. Application of the CFD Method for Heat Transfer Simulation. Proceedings of XLII Int. Conference ICEST, 24-27 June, Ohrid, 2007, pp. 815-818.

[6] Arnaudov, R., A. Andonova, N. Kafadarova, S. Andreev, V. Videkov. Experimental Characterization of 3D Micro-contacts. Proceedings of ISSE2008, Budapest, Hungary, 7-11 May 2008, pp.314-319.



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