

# **A DECISION-SUPPORT FRAMEWORK FOR THE DESIGN AND APPLICATION OF RADIANT COOLING SYSTEMS**

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State  
University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

In

Architecture and Design Research

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Elizabeth Grant

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Blacksburg, VA

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Mandates, Decision Mapping

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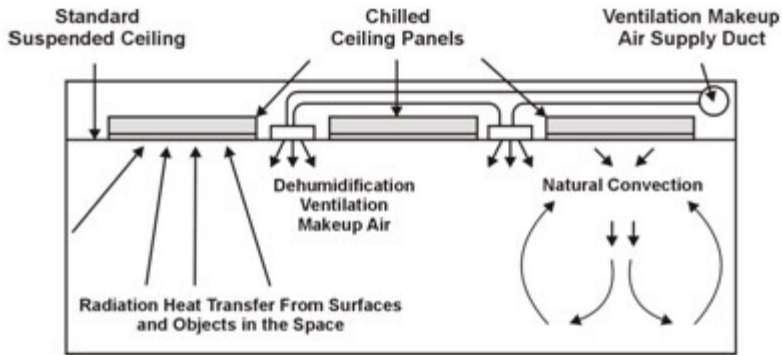
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I would greatly appreciate your consent to this request.

Best Regards,  
Shouib Mabdeh

-----  
**Shouib Mabdeh**

Ph.D. Candidate,  
Architecture and Design Research  
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Best regards,

Mark

Mark S. Hudoba, LEED GA  
Sr. Product Manager - Heating and Cooling  
Marketing and Offerings Department

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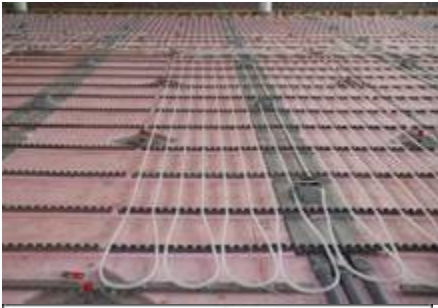
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**Sent:** Monday, January 03, 2011 12:56 PM  
**To:** Shouib Mabdeh  
**Subject:** RE: Radiant Cooling research project- PhD dissertaton

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Please feel free to contact me if I can still be of assistance.

Kind regards,

Mark

Mark S. Hudoba, LEED GA  
Sr. Product Manager - Heating and Cooling  
Marketing and Offerings Department

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**Sent:** Tuesday, August 03, 2010 10:32 AM  
**To:** Hudoba, Mark  
**Subject:** Radiant Cooling research project- PhD dissertaton

Dear Sir/Madame,

My name is Shouib Mabdeh and I am a Ph.D. student in the School of Architecture + Design at Virginia Tech . My research dissertation is concerned with the collaboration between architecture and engineering, particularly as it relates to design of Radiant Cooling systems under the title of: **A Decision-Support Framework for the Design and Application of Radiant Cooling Systems.**

For this research, through literature review, a series of case studies, and interviews with experienced professionals such as yourself, I intend to capture and structure knowledge related to how decisions are made concerning the integration of Radiant Cooling (RC) systems into mid-sized non-residential buildings. Through this knowledge capturing procedure the relevant design performance mandates, barriers and constraints to implementation, and potential advantages and benefits of radiant cooling systems will be determined and mapped to a decision-support framework with graphical representation. This knowledge-capturing process will also include identifying evaluation procedures for performance prediction of RC systems. The ultimate goal of this research is to then develop a design assistance tool for architects and HVAC engineers that could be adapted to a Building Information Modeling (BIM) domain.

As a leading company in the design and implementation of radiant cooling systems in North America, your help and assistance would be very valuable in meeting my research goals and toward development of the decision-support framework. In particular, with your assistance I hope to:

1. Identify different case studies within the USA where radiant cooling systems (in the ceiling and in the floor) are used and installed. It would be more helpful and useful if these case studies are located in different climatic zones.
2. Identify different parties (architects and HVAC engineers) who were involved in radiant cooling system projects to participate in the proposed interview later this year.

As part of your participation in this research I would be happy to make the results and findings available to you and your firm before they are made available to the public. Your help and contribution to my research would be very much appreciated. If you are willing to participate in my research please let me know so that we might begin the process through communication.

Please find my research white-page in the attached file

Regards,

Shouib Mabdeh

---

**Shouib Mabdeh**

Ph.D. Candidate,  
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## Shouib Mabdeh

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**Subject:** RE: copyright permission

**Categories:** Green Category



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Juan Rudek  
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Thank you,

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**Subject:** copyright permission

Dear Sir/Madam,

I am a student at Virginia Tech University and I have prepared a PhD dissertation entitled “ A Decision-Support Framework for the Design and Application of Radiant Cooling Systems”.

May I have your permission to include the following figure from your publication:  
The Capillary tubes for radiant cooling.

<http://www.naturalcooling.com/4.htm>

I would greatly appreciate your consent to this request.

Best Regards,  
Shouib Mabdeh

---

**Shouib Mabdeh**

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Name: shouib Ma'bdeh

Description of item under review for fair use: Figure 1.5. Active chilled beams (Active radiant cooling system)  
Source: (SmithGroup, <http://www.smithgroup.com/?id=1338>)

Report generated on: 10-23-2011 at : 16:15:08

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Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***against fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***



## Shouib Mabdeh

---

**From:** Sondra Jarvis [sajarvis@lbl.gov]  
**Sent:** Thursday, October 27, 2011 3:15 PM  
**To:** Shouib Mabdeh  
**Subject:** Re: Copyright permission

**Categories:** Green Category

Shouib,

You are more than welcome to use the concrete core system illustration in your dissertation. Please include a credit line attributing the photo to Lawrence Berkeley National Laboratory.

Sincerely,

Sondra Jarvis  
EETD Web Master

On 10/20/11 4:43 PM, Shouib Mabdeh wrote:

Dear Sir/Madam,

I am a student at Virginia Tech University and I have prepared a PhD dissertation entitled “ A Decision-Support Framework for the Design and Application of Radiant Cooling Systems”.

May I have your permission to include the following figure from your publication:  
Chilled slab with thermally active ceilings ( Concrete core system).

[http://eetdnews.lbl.gov/cbs\\_nl/nl04/cbs-nl4-cooling.html](http://eetdnews.lbl.gov/cbs_nl/nl04/cbs-nl4-cooling.html)

I would greatly appreciate your consent to this request.

Best Regards,  
Shouib Mabdeh

---

**Shouib Mabdeh**

Ph.D. Candidate,  
Architecture and Design Research  
School of Architecture+Design  
College of Architecture & Urban Studies  
Virginia Polytechnic Institute and State University

Blacksburg, 24061, Virginia  
(+1)(540)(808-5853)

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<http://www.radiantcompany.com/details/grade.shtml>

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<http://www.airfloor.com/aero2.htm#1>

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**Based on the information you provided, your use of the copyrighted work weighs: *in***

*favor of fair use*





**Title:** Five Misunderstandings About Case-Study Research  
**Author:** Bent Flyvbjerg  
**Publication:** Qualitative Inquiry  
**Publisher:** Sage Publications  
**Date:** 04/01/2006

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**Sent:** Monday, October 24, 2011 4:37 AM  
**To:** 'Shouib Mabdeh'  
**Subject:** RE: Copyright Permission

**Categories:** Green Category

Dear Shouib,

Many thanks for your email. Please allow me to introduce myself. My name is Laura Jenkins and I am the Rights Assistant here at Emerald. I am pleased to say that subject to full referencing I can grant you free permission to include the material detailed below within your dissertation;

**Developments in Appraising the Total Performance of Buildings  
James Douglas (pp. 10 - 15)**

**Table I.** Building Performance Appraisals: Implementing the Assessment

Please note however that if in the future you publish your dissertation you will need to clear permission again.

Good luck with your dissertation,

Kind Regards,

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**From:** Shouib Mabdeh [<mailto:mabdehsn@vt.edu>]  
**Sent:** 24 October 2011 02:04  
**To:** Permissions  
**Subject:** Copyright Permission

Dear Sir/Madam,

I am a student at Virginia Tech University and I have prepared a PhD dissertation entitled "A Decision-Support Framework for the Design and Application of Radiant Cooling Systems".

May I have your permission to include the following figures from your publication:

**Structural Survey**

**ISSN: 0263-080X**

**Volume 12 issue 6**

**Published: 1994, Start page: p4**

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James Douglas (pp. 10 - 15)**

**Table I.** Building Performance Appraisals: Implementing the Assessment

I would greatly appreciate your consent to this request.

Best Regards,  
Shouib Mabdeh

---

**Shouib Mabdeh**

Ph.D. Candidate,  
Architecture and Design Research  
School of Architecture+Design  
College of Architecture & Urban Studies  
Virginia Polytechnic Institute and State University

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**Shouib Mabdeh**

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Name: Shouib Ma'bdeh

Description of item under review for fair use: Figure 3.7. Relevant Building Performance Mandates (BPM) Figure 3.8. BPM interaction with different building systems Source: The Building Systems Integration Handbook (1986) by Richard Rush

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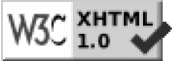
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Title of new book	A Decision-Support Framework for the Design and Application of Radiant Cooling Systems
Publisher of new book	Virginia Polytechnic Institute and State University
Author of new book	Shouib Mabdeh
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Author of new book	Shouib Mabdeh
Expected publication date of new book	Nov 2011
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**Publication:** ASHRAE Standards

**Publisher:** ASHRAE

**Date:** 2004

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Author of new book	Shouib Mabdeh
Expected publication date of new book	Nov 2011
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Author of new book	Shouib Mabdeh
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## Shouib Mabdeh

---

**From:** William Fisk [wjfisk@lbl.gov]  
**Sent:** Thursday, October 20, 2011 12:00 PM  
**To:** Shouib Mabdeh  
**Subject:** Re: copyright permission

**Categories:** Green Category

Yes, you have our permission as long as you cite the source.

Best regards

William Fisk

On Wed, Oct 19, 2011 at 6:20 PM, Shouib Mabdeh <[mabdehsn@vt.edu](mailto:mabdehsn@vt.edu)> wrote:

Dear Sir/Madam,

I am a student at Virginia Tech University and I have prepared a PhD dissertation entitled “ A Decision-Support Framework for the Design and Application of Radiant Cooling Systems”.

May I have your permission to include the following figure from your publication:

Figure 2. Predicted performance of office work at various ventilation rates relative to performance at the indicated reference ventilation rates

<http://www.iaqscience.lbl.gov/vent-office.html>

I would greatly appreciate your consent to this request.

Best Regards,

Shouib Mabdeh

---

**Shouib Mabdeh**

Ph.D. Candidate,

Architecture and Design Research

School of Architecture+Design

College of Architecture & Urban Studies

Virginia Polytechnic Institute and State University

Blacksburg, 24061, Virginia

(+1)(540)(808-5853)

--

William J. Fisk

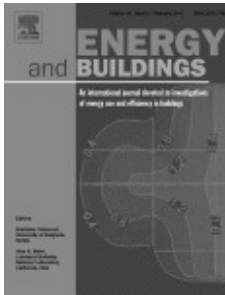
Sr Scientist, Department Head

Indoor Environment Department

Lawrence Berkeley National Laboratory

<http://eetd.lbl.gov/IED/>

[www.iaqscience.lbl.gov](http://www.iaqscience.lbl.gov)



**Title:** A critical review on the performance and design of combined cooled ceiling and displacement ventilation systems

**Author:** Atila Novoselac, Jelena Srebric

**Publication:** Energy and Buildings

**Publisher:** Elsevier

**Date:** June 2002

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Order reference number	Figure.1: ASHRAE Journal, Vol.48, Issue.10. P.65-66
Title of new book	A Decision-Support Framework for the Design and Application of Radiant Cooling Systems
Publisher of new book	Virginia Polytechnic Institute and State University
Author of new book	Shouib Mabdeh
Expected publication date of new book	Nov 2011
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## Virginia Tech ETD Fair Use Analysis Results

*This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.*

Name: Shouib Ma'bdeh

Description of item under review for fair use: Figure 3.39. The simulation results of the energy consumption of the different cooling strategies for Denver, Colorado Figure 3.40. The simulation results of the energy consumption of the different cooling strategies for Sacramento, California Figure 3.41. The simulation results of the energy consumption of two different cooling strategies for Los Angeles, California Figure 3.42. The simulation results of the energy consumption of two different cooling strategies for San Francisco, California Figure 3.43. The peak power demand for the different cooling strategies for the day of peak cooling loads in Sacramento, California Source: Simulation of Radiant Cooling Performance With Evaporative Cooling Sources (2008) by Timothy Moore

Report generated on: 11-09-2011 at : 00:41:41

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

Based on the information you provided, your use of the copyrighted work weighs: ***in favor of fair use***



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## **Virginia Tech ETD Fair Use Analysis Results**

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Name: Shouib Ma'bdeh

Description of item under review for fair use: Figure 3.46. Decisions types Source: Making Hard Decisions an introduction to decision analysis, 1996, by Robert Clemen

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#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***against fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***



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Name: Shouib Ma'bdeh

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#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***against fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***





## Shouib Mabdeh

---

**From:** Christa Hartsock [chartsock@roseandpartners.com]  
**Sent:** Tuesday, November 01, 2011 11:08 PM  
**To:** Shouib Mabdeh  
**Subject:** RE: Copyright Permission

**Categories:** Green Category

Dear Shouib Mabdeh,

Both Peter Rose + Partners and the photographer, Matthew Snyder, grant permission to include the photographs for academic use. Would it be possible to receive a digital copy of the dissertation once complete? Thank you very much for including us in your research.

Best regards,  
Christa

**Christa Hartsock**

Peter Rose + Partners  
1Kendall Square, Ste B17002, Cambridge, MA 02139  
Tel 617.494.8115 Fax 617.494.0404

[www.roseandpartners.com](http://www.roseandpartners.com)

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**From:** Shouib Mabdeh [<mailto:mabdehsn@vt.edu>]  
**Sent:** Monday, October 24, 2011 9:17 PM  
**To:** Christa Hartsock  
**Subject:** Copyright Permission

Dear Sir/Madam,

I am a student at Virginia Tech University and I have prepared a PhD dissertation entitled "A Decision-Support Framework for the Design and Application of Radiant Cooling Systems".

May I have your permission to include the photos from your website related to the Kripalu Center for Yoga and Health. I used the building as a case study.

I would greatly appreciate your consent to this request.

Best Regards,  
Shouib Mabdeh

---

**Shouib Mabdeh**  
Ph.D. Candidate,  
Architecture and Design Research  
School of Architecture+Design  
College of Architecture & Urban Studies  
Virginia Polytechnic Institute and State University

Blacksburg, 24061, Virginia  
(+1)(540)(808-5853)

## Shouib Mabdeh

---

**From:** Kevin Lippert [lippert@papress.com]  
**Sent:** Monday, October 24, 2011 9:59 PM  
**To:** mabdehsn@vt.edu  
**Cc:** customerservice@papress.com  
**Subject:** Re: Customer service request from Shouib Mabdeh

**Categories:** Green Category

On 10/24/11 9:50 PM, [mabdehsn@vt.edu](mailto:mabdehsn@vt.edu) wrote:

Hi,

Shouib Mabdeh has emailed us with the comment:

Dear Sir/Madam,

I am a student at Virginia Tech University and I have prepared a PhD dissertation entitled " A Decision-Support Framework for the Design and Application of Radiant Cooling Systems".

May I have your permission to include the photos related to Klarch Information Commons Center from your publication:  
Thermally Active Surfaces in Architecture

I would greatly appreciate your consent to this request.

Best Regards,  
Shouib Mabdeh

---

Shouib Mabdeh  
Ph.D. Candidate,  
Architecture and Design Research  
School of Architecture+Design  
College of Architecture & Urban Studies  
Virginia Polytechnic Institute and State University

Blacksburg, 24061, Virginia  
(+1) (540) (808-5853)

Book in question: Thermally Active Surfaces in Architecture

This customer's contact information:

name: Shouib Mabdeh  
phone: 5408085853  
email: [mabdehsn@vt.edu](mailto:mabdehsn@vt.edu)

Best time to contact this customer:  
10am-10pm

Dear Shouib,

Because you will be using this image in an academic publication (and, I assume, in black-and-white) for non-

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Thanks for asking, though,

Kevin

--

Kevin Lippert

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Name: Shouib Ma'bdeh

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Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *against fair use*

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

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## Virginia Tech ETD Fair Use Analysis Results

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Name: Shouib Ma'bdeh

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### **Based on the information you provided:**

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Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *against fair use*

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

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Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *against fair use*

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***



## Shouib Mabdeh

---

**From:** Carl D'Silva [cdsilva@murphyjahn.com]  
**Sent:** Thursday, October 20, 2011 2:56 PM  
**To:** mabdehsn@vt.edu  
**Subject:** RE: Copyright Permission

**Categories:** Green Category

Dear Shouib,

You hereby have permission to use the Bangkok figures in your dissertation.

Regards,

Carl D'Silva

---

**From:** Shouib Mabdeh [<mailto:mabdehsn@vt.edu>]  
**Sent:** Thursday, October 20, 2011 1:07 PM  
**To:** Info Box  
**Subject:** Copyright Permission

Dear Sir/Madam,

I am a student at Virginia Tech University and I have prepared a PhD dissertation entitled "A Decision-Support Framework for the Design and Application of Radiant Cooling Systems".

May I have your permission to include the 4 figures from your website publication talking about:

Suvarnabhumi International Airport.

<http://www.murphyjahn.com/BANGKOK.html>

I would greatly appreciate your consent to this request.

Best Regards,  
Shouib Mabdeh

---

**Shouib Mabdeh**  
Ph.D. Candidate,  
Architecture and Design Research  
School of Architecture+Design  
College of Architecture & Urban Studies  
Virginia Polytechnic Institute and State University

Blacksburg, 24061, Virginia  
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