| Date for Return to PI: (mm/dd/yy) | **CLEMSON UNIVERSITY**<br>**Sponsored Programs Internal Processing Form** | The Office for Sponsored Programs is committed to providing prompt proposal review. However, due to increased federal compliance requirements, proposals cannot be processed if all issues listed on the following page are not properly addressed prior to submission. All requested supporting attachments must be included with the proposal. |
|---|---|---|
| Name/phone for proposal pick-up | PROPOSAL PROCESSING NUMBER<br># 2007000878 | |

**PRINCIPAL INVESTIGATOR/CO-INVESTIGATORS – *LAST NAME FIRST***
**(FOR ADDITIONAL SPACES, USE SUPPLEMENT #1)**

| Principal Investigator/Co-Investigators (List Principal Investigator First) | CUBS assigned Dept Number | E-mail Address | Credit to Project * (Must Total 100%) |
|---|---|---|---|
| J. M. Westall | 0974 | westall@cs.clemson.edu | 16.7 |
| T. A. Davis | 0974 | tadavis@cs.clemson.edu | 16.7 |
| R. M. Geist | 0974 | rmg@es.clemson.edu | 16.7 |
| | | | 0.00 |

* *Indicate desired credit distribution for each investigator to be applied to fiscal year award dollars, project expenditures, and incentive return.*

**IF APPLICABLE,** Unit number of Center/Institute responsible for project. [ ] Center Director Signature/Date

**Proposal Title** CPATH EAE: TEXNH - Evaluation, Adoption and Extension

**Funding Agency** NSF

**Prog/Solicitation #** 06-608 **Prog Title or Acronym:** CPATH

**Period Covered:** (mm/dd/yy) From: 1 Jul 07 To: 1 July 10

**Submission Type:**
- (•) New
- ( ) Budget Revision, provide Proposal # _____
- ( ) Additional Funding, provide Project # _____

**Classification:**
- ( ) Instruction
- (•) Research
- ( ) Public Service
- ( ) Ag Regulatory
- ( ) Regulatory
- ( ) Other Sponsored Activity

**Foreign Sponsor?**
- ( ) Yes
- (•) No

[redacted]

1 – Post-doc 1 yr

**EMPHASIS AREA:** (Select only one per project.)
- (•) Advanced Materials
- ( ) Automotive & Transportation Technology
- ( ) Biotechnology & Biomedical Sciences
- ( ) Family & Community Living
- ( ) Other (Not covered in listed Emphasis Areas)
- ( ) General Education
- (X) Information & Communications Technology
- ( ) Leadership & Entrepreneurship
- ( ) Sustainable Environment

Amount to Subcontract (if applicable): 97,398 — Documentation from subcontractor required.

Amount Cost Sharing (if applicable): [ ] — If cost sharing is proposed, a fully approved Cost Share Agreement (OSP-1A) must be attached.

**REQUESTED FUNDS:**

| Direct Costs ($) | F&A (Indirect) Costs ($) | TOTAL |
|---|---|---|
| 353,909 | 134,257 | 488,167 |

**COLLEGE USE (IF REQUIRED)**

| | | |
|---|---|---|
| ○ Overnight<br>○ Certified<br>○ Fax<br>○ Return to PI | Complete address, fax # or special instructions | In<br>Out 1123107 |

**SPONSORED PROGRAMS USE ONLY**

**F&A Rate Comparison Information:**
- % Approved by DHHS 47
- % Allowed by Sponsor Policy 47
- % Applied to this Project 47

Date In

Date Out

| CFDA | Grants Coord Init'ls | Program | Subclass | OSP-1 |
|---|---|---|---|---|
| 47.049 | JM | 20 | 206 | Revised 7/2004 |

| Yes | No | |
|---|---|---|
| ☐ | ☒ | Does this project support K-12 teacher preparation/professional development/applied research? |
| ☐ | ☒ | Did the Clemson University Development Office assist in this proposal? |
| ☐ | ☒ | Does project require submission through CURF (Clemson University Research Foundation)? IF YES, contact OSP @ 656-2424 |
| ☐ | ☒ | Does sponsor's policy (federal or non-profit only) prohibit F&A costs? IF YES, attach copy of policy. |
| ☐ | ☒ | Does sponsor's policy require mandatory cost sharing or matching funds? IF YES, attach copy of policy. |
| ☒ | ☐ | Is proposal responding to a Request for Proposal (RFP) or program announcement? IF YES, attach copy. |
| ☐ | ☒ | Does project require foreign travel or employment? IF YES, contact Human Resources (employment); Comprtroller (travel). |
| ☐ | ☒ | Does project involve federal classified, ITAR, or export controlled information? IF YES, contact Facilities Security Officer @ 656-5515. |
| ☐ | ☒ | Is project likely to involve publication restrictions? IF YES, check one: ☐ *BY SPONSOR* ☐ *BY CLEMSON* |
| ☐ | ☒ | Does project involve confidential information or trade secrets? IF YES, check one: ☐ *OF SPONSOR* ☐ *OF CLEMSON* |
| ☐ | ☒ | Does project have intellectual property (patents) potential? IF YES, contact Tech Transfer Office @ 656-4237 |
| ☒ | ☐ | Space is available and facilities are suitable? If NO, attach a memo from immediate supervisor addressing remedy. If facility modifications exceed $100K, include copy of FM&O's cost estimate. |
| ☐ | ☒ | If federally funded, have university funds been used to lobby for this project? |

## COMPLIANCE DATA

| Yes | No | | | mm/dd/yy |
|---|---|---|---|---|
| ☐ | ☒ | **HUMAN SUBJECTS?** | Protocol Number _____ | Approval Date _____ |
| ☐ | ☒ | **ANIMAL SUBJECTS?** | Protocol Number _____ | Approval Date _____ |
| | | *Federal Wide Assurance (FWA) #00004497* | | |
| ☐ | ☒ | **BIOHAZARD/CHEMICAL?** | Protocol Number _____ | Approval Date _____ |
| ☐ | ☒ | **RECOMBINANT DNA?** | Protocol Number _____ | Approval Date _____ |

My signature certifies my awareness that, (1) a copy of this proposal is being provided to the appropriate Clemson University compliance committee(s) by the Office of Sponsored Programs; (2) a Clemson University-approved active protocol is required prior to initiation of activities outlined in this proposal; (3) Clemson University's compliance committee(s) must approve protocols for external performers and/or off-site activities, i.e., GHS. (4) I must complete all training & education programs required Clemson University prior to performing research compliance activities.

James M Westall

**Signature of Principal Investigator**

## ADDITIONAL CERTIFICATIONS AND APPROVAL SIGNATURES

Financial Disclosure: The undersigned certify that they have read, understand, and are bound by Clemson University's FINANCIAL DISCLOSURE policy, that they have made all financial disclosures required by it, if any, and will comply with any conditions or restrictions imposed by the institution to manage, reduce, or eliminate actual or potential **conflicts of interest**. Intellectual Property: The undersigned certify that they have read, understand, and are bound by Clemson University's patent policy and computer software copyright policy, agree to assign all rights, title, and interest in intellectual property under such policies to Clemson University, and to execute such further documents needed to perfect the assignment of such rights. All investigators agree to disclose, and to cause other project personnel to disclose, all INTELLECTUAL PROPERTY to the University Intellectual Property Committee within 60 days of discovery or the time of confidential submission for publication of manuscripts disclosing the invention, whichever is earlier. Failure to make timely disclosure to the Committee may lead to the loss of patent rights to the federal government on federal government contracts or to other parties. Cost Accounting Standards: The principal investigator certifies that the proposal budget complies with Clemson University's federal cost accounting standards policy.

| *ASD*** | | *Printed/Typed Name* | *Signature* | *Date* |
|---|---|---|---|---|
| ☐ | **PRINCIPAL INVESTIGATOR** | James M Westall | James M Westall | 22 Jan 07 |
| ☐ | Dept Head/Director/Chair * (as required by College) | Robert M Geist | Robert M Geist | 1/22/07 |
| ☐ | Dean or School Official* | R Larry Dudley | R Larry Dudley | 1/23/07 |
| ☐ | **CO-INVESTIGATORS** | Timothy A Davis | Timothy A Davis | 1/22/07 |
| ☐ | Dept Head/Director/Chair (as required by College) | | | |
| ☐ | Dean or School Official | | | |

* Signature includes the representation that sufficient facilities are available for project performance.

** ASD – Alternate Signature Designee – For example approval in the absence of the PI. Check only one box.

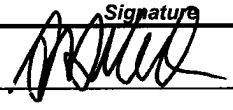
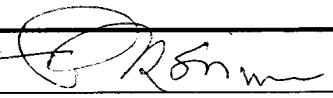
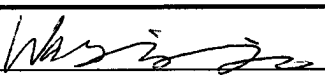
| DUPLICATE AS NEEDED | **CLEMSON UNIVERSITY**<br>***Sponsored Programs Processing Form***<br>***SUPPLEMENT #1*** | **OSP Number**<br>**College Use** |
|---|---|---|

## ADDITIONAL CO-INVESTIGATORS – *LAST NAME FIRST*

| Co-Investigators | Dept # | E-mail Address | Credit to Project (Must total 100%) |
|---|---|---|---|
| A. Duchowski | 0974 | andrewd@ces.clemson.edu | 11.7 |
| P. Srimani | 0974 | srimani@cs.clemson.edu | 16.3 |
| J. Wang | 0974 | j-zwang@cs.clemson.edu | 16.7 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## ADDITIONAL CERTIFICATION AND APPROVAL SIGNATURES

Financial Disclosure: The undersigned certify that they have read, understand, and are bound by Clemson University's FINANCIAL DISCLOSURE policy, that they have made all financial disclosures required by it, if any, and will comply with any conditions or restrictions imposed by the institution to manage, reduce, or eliminate actual or potential **conflicts of interest**. Intellectual Property: The undersigned certify that they have read, understand, and are bound by Clemson University's patent policy and computer software copyright policy, agree to assign all rights, title, and interest in intellectual property under such policies to Clemson University, and to execute such further documents needed to perfect the assignment of such rights. All investigators agree to disclose, and to cause other project personnel to disclose, all INTELLECTUAL PROPERTY to the University Intellectual Property Committee within 60 days of discovery or the time of confidential submission for publication of manuscripts disclosing the invention, whichever is earlier. Failure to make timely disclosure to the Committee may lead to the loss of patent rights to the federal government on federal government contracts or to other parties. Cost Accounting Standards: The principal investigator certifies that the proposal budget complies with Clemson University's federal cost accounting standards policy.

| *ASD** | | *Printed/Typed Name* | *Signature* | *Date* |
|---|---|---|---|---|
| ☐ | **CO-INVESTIGATOR** | A. Duchowski |  | 1/22/07 |
| ☐ | Dept Head/Director/Chair (as required by College) | | | |
| ☐ | Dean or School Official | | | |
| ☐ | **CO-INVESTIGATOR** | P. Srimani |  | 1/22/07 |
| ☐ | Dept Head/Director/Chair (as required by College) | | | |
| ☐ | Dean or School Official | | | |
| ☐ | **CO-INVESTIGATOR** | J. Wang |  | 1/22/07 |
| ☐ | Dept Head/Director/Chair (as required by College) | | | |
| ☐ | Dean or School Official | | | |

**Note:** Only one signature for each Dean, Department Head, Director or Chair necessary for multiple co-investigators under their supervision.
*** ASD** – Alternate Signature Designee – For expenditure approval in the absence of the PI. Check only one.

To be completed by Dept./College Grant Coordinator at the PI's

# CU Internal Budget Form for Sponsored Projects

Cost Sharing should be submitted on a separate form

| Exclude from Indirect Base? | CU Budget Category | Dept. or Year 1 | Dept. Or Year 2 | Dept. Or Year 3 | Dept. Or Year 4 | Dept. Or Year 5 | Total Budget |
|---|---|---|---|---|---|---|---|
| | Classified Salaries (CLASS) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Unclassified Salaries (UCLASS) | 63,171.00 | 32,531.00 | 33,508.00 | 0.00 | 0.00 | 129,210.00 |
| | Graduate Salaries (GRAD) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Hourly Employees (WAGES) | 40,000.00 | 0.00 | 0.00 | 0.00 | 0.00 | 40,000.00 |
| | Fringe Benefits (FRINGE) | 26,652.00 | 7,710.00 | 7,941.00 | 0.00 | 0.00 | 42,303.00 |
| | Masters Graduate Assist. Differential (MASGAD) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ✓ | PhD Graduate Assist. Differential (PHDGAD) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Travel Expenses (TRAVEL) | 15,000.00 | 15,000.00 | 15,000.00 | 0.00 | 0.00 | 45,000.00 |
| | Other Costs (OTHER) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Student Aid (STUAID) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Participant Support Costs (PARTSP) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Subcontract Costs (SUBCON) | 48,699.00 | 48,699.00 | 0.00 | 0.00 | 0.00 | 97,398.00 |
| ✓ | Equipment (EQUIP) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Total Direct Costs | 193,522.00 | 103,940.00 | 56,449.00 | 0.00 | 0.00 | 353,911.00 |
| Rate 47 % | Indirect Costs (FACADM) | 79,205.00 | 28,521.00 | 26,531.00 | 0.00 | 0.00 | 134,257.00 |
| | Total Project Budget | 272,727.00 | 132,461.00 | 82,980.00 | 0.00 | 0.00 | 488,168.00 |

Prepared By: _____

| | YEAR 1 | YEAR 2 | YEAR 3 | TOTAL |
|---|---|---|---|---|
| Personnel | | | | |
| Westall | 11,908 | 6,133 | 6,317 | 24,358 |
| Davis | 9,683 | 4,987 | 5,137 | 19,807 |
| Geist | 14,102 | 7,263 | 7,481 | 28,846 |
| Srimani | 7,390 | 3,806 | 3,920 | 15,116 |
| Wang | 9,436 | 4,856 | 5,002 | 19,294 |
| Duchowski | 10,652 | 5,486 | 5,651 | 21,789 |
| Other Personnel | | | | |
| Post-Doc | 40,000 | 0 | 0 | 40,000 |
| Total Salary and wages | 103,171 | 32,531 | 33,507 | 169,209 |
| Fringe Benefits | 26,652 | 7,710 | 7,941 | 42,303 |
| Total Salary and Wages | 129,823 | 40,241 | 41,448 | 211,511 |
| Equipment | 0 | 0 | 0 | 0 |
| Travel | 15,000 | 15,000 | 15,000 | 45,000 |
| Participant Support costs | | | | 0 |
| Materials and Supplies | 0 | 0 | 0 | 0 |
| Publication Costs | | | | 0 |
| Other | 0 | 0 | 0 | 0 |
| Tuition Remission | 0 | 0 | 0 | 0 |
| ***($9,929 for '06 + 5% ann incr)*** | | | | |
| Subcontract | 0 | 0 | 0 | 0 |
| UNCW | 19,557 | 19,557 | 0 | 39,114 |
| Western Carolina | 29,142 | 29,142 | 0 | 58,284 |
| Total Other Direct Costs | 48,699 | 48,699 | 0 | 97,398 |
| Total Direct costs | 193,522 | 103,940 | 56,448 | 353,909 |
| Indirect costs | 79,205 | 28,521 | 26,531 | 134,257 |
| Total Proposed costs | 272,727 | 132,461 | 82,979 | 488,167 |

## 02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

**PI/PD Name:** James Westall

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

**Citizenship:** (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

**Check here if you do not wish to provide any or all of the above information (excluding PI/PD name):** ☒

**REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project** ☒

**Ethnicity Definition:**
**Hispanic or Latino.** A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

**Race Definitions:**
**American Indian or Alaska Native.** A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
**Asian.** A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
**Black or African American.** A person having origins in any of the black racial groups of Africa.
**Native Hawaiian or Other Pacific Islander.** A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
**White.** A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

**WHY THIS INFORMATION IS BEING REQUESTED:**

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

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**PI/PD Name:** Timothy A Davis

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

**Citizenship:** (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

**Check here if you do not wish to provide any or all of the above information (excluding PI/PD name):** ☒

**REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project** ☐

**Ethnicity Definition:**
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**Race Definitions:**
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**Black or African American.** A person having origins in any of the black racial groups of Africa.
**Native Hawaiian or Other Pacific Islander.** A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
**White.** A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

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**PI/PD Name:** Andrew T Duchowski

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

**Citizenship:** (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

**Check here if you do not wish to provide any or all of the above information (excluding PI/PD name):** ☐

**REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project** ☒

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**PI/PD Name:** Robert M Geist

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

**Disability Status:** (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

**Citizenship:** (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

**Check here if you do not wish to provide any or all of the above information (excluding PI/PD name):** ☒

**REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project** ☒

**Ethnicity Definition:**
**Hispanic or Latino.** A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

**Race Definitions:**
**American Indian or Alaska Native.** A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
**Asian.** A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
**Black or African American.** A person having origins in any of the black racial groups of Africa.
**Native Hawaiian or Other Pacific Islander.** A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
**White.** A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

**WHY THIS INFORMATION IS BEING REQUESTED:**

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

## 02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

**PI/PD Name:** Zijun Wang

**Gender:** ☒ Male ☐ Female

**Ethnicity:** (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

**Race:** (Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

**Disability Status:** (Select one or more)
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- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

**Citizenship:** (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

**Check here if you do not wish to provide any or all of the above information (excluding PI/PD name):** ☐

**REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project** ☐

**Ethnicity Definition:**
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Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

## List of Suggested Reviewers or Reviewers Not To Include (optional)

**SUGGESTED REVIEWERS:**
Not Listed

**REVIEWERS NOT TO INCLUDE:**
Not Listed

# COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 04-23

NSF 06-608 01/23/07

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

CCF - CPATH

**FOR NSF USE ONLY**

**NSF PROPOSAL NUMBER**

**0722313**

| DATE RECEIVED | NUMBER OF COPIES | DIVISION ASSIGNED | FUND CODE | DUNS# (Data Universal Numbering System) | FILE LOCATION |
|---|---|---|---|---|---|
| 01/23/2007 | 10 | 05010000 CCF | 7640 | 042629816 | 01/24/2007 8:33am S |

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

576000254

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Clemson University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0034256000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

300 BRACKETT HALL
BOX 345702
CLEMSON, SC 29634-5702

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **CPATH EAE: TEXNH - Evaluation, Adoption and Extension**

| REQUESTED AMOUNT | PROPOSED DURATION (1-60 MONTHS) | REQUESTED STARTING DATE | SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE |
|---|---|---|---|
| $ 488,168 | 36 months | 07/01/07 | |

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.A)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.B, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.5) IACUC App. Date _____
☐ HUMAN SUBJECTS (GPG II.D.6)
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Computer Science

PI/PD FAX NUMBER
864-656-0145

PI/PD POSTAL ADDRESS
Edwards Hall
Box 340974
Clemson, SC 296340974
United States

| NAMES (TYPED) | High Degree | Yr of Degree | Telephone Number | Electronic Mail Address |
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| CO-PI/PD<br>Timothy A Davis | Ph.D | 1998 | 864-656-0309 | tadavis@cs.clemson.edu |
| CO-PI/PD<br>Andrew T Duchowski | PhD | 1997 | 864-656-7677 | andrewd@cs.clemson.edu |
| CO-PI/PD<br>Robert M Geist | PhD | 1974 | 864-656-2258 | rmg@cs.clemson.edu |
| CO-PI/PD<br>Zijun Wang | PhD | 2001 | 864-656-7678 | jzwang@cs.clemson.edu |



Electronic Signature

# CERTIFICATION PAGE

## Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-23. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

### Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Appendix C of the Grant Proposal Guide.

### Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Appendix D of the Grant Proposal Guide.

### Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

### Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

| AUTHORIZED ORGANIZATIONAL REPRESENTATIVE | SIGNATURE | DATE |
|---|---|---|
| NAME<br>**Dianne M Myers** | **Electronic Signature** | **Jan 23 2007 5:29PM** |

| TELEPHONE NUMBER | ELECTRONIC MAIL ADDRESS | FAX NUMBER |
|---|---|---|
| **864-656-5534** | **dmmyers@clemson.edu** | **864-656-7244** |

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

# CERTIFICATION PAGE

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| AUTHORIZED ORGANIZATIONAL REPRESENTATIVE | | SIGNATURE | DATE |
|---|---|---|---|
| NAME | | | 1/23/07 |
| TELEPHONE NUMBER | ELECTRONIC MAIL ADDRESS | | FAX NUMBER |

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

## B. Project Summary.

In the year 2003, a group of faculty in the Department of Computer Science at Clemson University sought funding from the NSF to undertake a zero-based redesign of the B.A. degree in Computer Science. This project, entitled "τέχνη: A New Approach to the B.A. Degree in Computer Science," was funded by the NSF (CISE/EIA) in July, 2003 and will be completed at the end of this academic year.

As a result of the project, the Department of Computer Science has restructured not only the B.A. degree program but also the first two years of the B.S. degrees in Computer Science and in Computer Information Systems around the τέχνη approach. The two-year curriculum implemented in the τέχνη project is based upon problem-based instruction in the domain of computer generated visual media. Problem-based instruction is used as a vehicle, but course design differs from others in the depth, scope, and open-ended nature of the problems employed. Problems domains are non-traditional and selected specifically to attract and motivate students. A problem domain is matched to a specific course based upon its suitability to support the learning goals of the course. Problems are open-ended so that the best students can be challenged, but the average student is provided a pathway to success at the highest level at which he or she is capable.

In the project proposed here, the success of the τέχνη project will be built upon in a manner that is well aligned with the objectives of the CISE CPATH EAE program. A rigorous embedded assessment mechanism will be introduced into new and existing courses to measure the degree to which stated learning outcomes are being achieved. The work of Walker and Fraser [13] and the dynamic assessment of Brown [10] which is based upon Vygotsky's zones of proximal development [12] will serve as the foundation on which the assessment mechanisms are built.

The τέχνη approach will be adopted by two partner universities. Each will teach one course for at least two years, and the PIs will identify other courses in their curricula to which the approach might be extended. Our new assessment mechanism will be used by all partners. Course materials including detailed lecture notes will be made available on the web to facilitate adoption on a nation-wide scale. The τέχνη approach will be extended to senior division courses at Clemson and to an introductory computing course used by pre-engineering students at one partner.

**Intellectual Merit.** New science will accrue from the project in two related areas. One will be in the development of quantitative assessment mechanisms that can address the difficult problem of measuring the effectiveness of constructivist approaches to learning. The second will be in applying those mechanisms to identify common characteristics of the problem domains adjudged most successful.

**Broader Impact.** Because of its use of well-designed problems taken from domains involving computing and popular culture, we believe the widespread adoption of the τέχνη approach will have a broad and positive impact on the size and competency of the computing workforce. It will attract more students to computing. It will attract better students to computing. It will motivate and thus retain the students that it attracts, and the students it produces will be well-equipped to take on the challenges and opportunities provided by the rapidly evolving field of computing.

The Clemson graduate program in digital production arts that inspired the development of the τέχνη curriculum consistently has a significantly higher percentage of women and minorities than the graduate and undergraduate programs in computer science. Thus, an additional impact is that the τέχνη approach, with its similar emphasis on creative design, may attract more women and minorities into computing.

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| Table of Contents | 1 | |
| Project Description (Including Results from Prior NSF Support) (not to exceed 15 pages) **(Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)** | 15 | |
| References Cited | 3 | |
| Biographical Sketches (Not to exceed 2 pages each) | 20 | |
| Budget (Plus up to 3 pages of budget justification) | 14 | |
| Current and Pending Support | 3 | |
| Facilities, Equipment and Other Resources | 0 | |
| Special Information/Supplementary Documentation | 0 | |
| Appendix (List below. ) **(Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)** | | |
| Appendix Items: | | |

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

## D. Project Description.

In the year 2003, a group of faculty in the Department of Computer Science at Clemson University sought funding from the NSF to undertake a zero-based redesign of the B.A. degree in Computer Science. This project, entitled "τέχνη: A New Approach to the B.A. Degree in Computer Science," was funded by the NSF (CISE/EIA) in July, 2003 and will be completed at the end of this academic year.

As a result of this project, the Department of Computer Science has restructured not only the B.A. degree program but also the first two years of the B.S. degrees in Computer Science and in Computer Information Systems around the τέχνη approach. At the end of the current academic year, two courses at the freshman level and two more at the sophomore level will be in place.

The word, τέχνη, in the title of the proposal, is the Greek word for *art*. It is also the root of the word τεχνολογία, the Greek word for *technology*. It is unfortunate that this strong connection between the two, established in the language of those who took a foundational role in both, has been largely lost by the U.S. educational system. Today undergraduate curricula in computing are laden with computing-specific requirements that allow little time for exploration of disciplines outside science, let alone the connections between each of those disciplines and computing.

The two-year curriculum implemented in the τέχνη project is based upon problem-based instruction in the domain of computer generated visual media. We use problem-based instruction as a vehicle, but our design differs from others in the depth, scope, and open-ended nature of the problems addressed. Our design process begins with an identification of course goals in terms of fundamental concepts and abilities to be acquired by the student during the course. In this endeavor, we recognize the rapidly changing nature of the computing discipline and focus on developing the skills needed to meet the challenges the student will face in the rapidly evolving computing environment.

Developing ability and enthusiasm for computational problem-solving, rather than experience with popular software or hardware platforms, is of paramount importance. To this end, we enumerate and categorize concepts in computing that we deem absolutely essential to computational problem-solving. We collect closely-related concepts to form the structural goals of individual courses and then identify semester-long problems from the visual domain that will invoke an exploration of these structures.

The new courses have engendered enthusiasm not only among the students, but also (as we had hoped) among the faculty Two faculty members are presently attending PI Westall's CS2. The project has also produced several publications in international venues including two in the SIGCSE Technical Symposium on Computer Science Education and one that was named "Best Paper" in the Eurographics Education Program in Sept. 2006.

In the work proposed here, PIs of the original τέχνη project will work with new participants to build upon its success in a way that we believe very well aligned with the objectives of the CISE CPATH EAE program. We will

- develop and implement more formal approaches to evaluation and assessment,
- work with colleagues at regional campuses of the University of North Carolina system in the adoption and evaluation of the τέχνη approach and,
- extend the τέχνη approach to include computing courses offered to non-computer science majors, to include additional problem domains, and to include senior division courses at Clemson.

## D.1. Project Vision, Objectives and Outcomes.

Twenty-five years ago a very small percentage of the population had ever seen a computer, let alone operated or programmed one. As such, participating in computing carried the ipso facto excitement associated with being involved in an esoteric high technology activity. At that time, computer science students typically encountered software development exercises taken from the areas of business systems (accounting, inventory, personnel); computer systems (operating system components, compilation); educational support systems (grade computation, course registration); or purely topic-driven (construct an AVL tree in which the nature of the elements to be managed is irrelevant).

In the intervening years since that time, computing has changed rapidly and profoundly. Computing systems now comprise critical components in industries that are crucial to the security, health, and economic welfare of the nation. Notable examples of such industries and applications include: communications (personal communication systems; digital TV, the Internet); entertainment (film and music production, distribution, and playback); national defense (intelligence and weapon systems); transportation (automotive and aircraft systems); and health (medical imaging and bioinformatics). Because of its very ubiquity, computing has lost much of the mystique it once possessed, and this has contributed to the problem of attracting the best students to the field.

While applications of computing have been changing at an astonishing pace, computing curricula have evolved quite slowly. Some aspects have clearly changed in fairly significant ways. The object-oriented paradigm has replaced structured programming as the "ultimate solution" to the software development problem. User interaction may now be via a web-based applet or tablet PC instead of a dumb terminal. Nevertheless, the problem domains from which student assignments are commonly taken have evolved little, if at all. Today's student is no longer excited nor motivated by acquiring the ability to build a toy grade averaging program or an inventory control database and questions the relevance of having to construct an AVL tree to print a collection of integers in sorted order. This perceived lack of excitement and relevance has doubtless contributed to the problems of attracting, motivating, and retaining students.

Another problem that confronts the curriculum designer in the non-elite university is how to attract and maintain the interest of the very best students in classes in which student aptitude varies tremendously. Assigning problems that challenge the most skilled can lead to withdrawal and failure rates among the average student that are unacceptable in times of declining enrollments. Conversely problems that target the average student may cause the best students to lose interest in the course.

Therefore, we envision a curriculum that

- attracts and challenges the very best students,
- motivates average students and provides them the skills they need to contribute to the rapidly changing computing field and,
- inspires faculty to stay abreast of leading-edge applications of computing.

Our goals in this project are to complete the implementation of such a curriculum at Clemson University, to initiate the development of comparable curricula at three partner universities, and to develop assessment mechanisms though which we can quantify the effectiveness of our efforts. The use of problem-based learning with open-ended problems chosen from leading-edge applications in non-traditional problem domains provides the foundation upon which we build. We believe that the use of such problem domains will attract, motivate and retain students of all abilities. It will also renew the enthusiasm of senior faculty whose courses may have become somewhat stale. The open-ended nature of the problems used in the τέχνη approach is

intended to motivate each student to achieve at the highest level that is commensurate with his or her ability. We have already observed several examples of intentional learning in which the very best students extended the problem and its solution in ways not even suggested in class.

It should be emphasized that we have not lost sight of the need for students to acquire a traditional collection of basic skills. To this end, we enumerate and categorize concepts in computer science that we deem essential to computational problem-solving. A collection of closely-related concepts forms the structural goals of an individual course.

At the completion of this project we will have completed the curriculum we envisioned four years ago. We will have obtained quantitative measures of its effectiveness. We will have planted the seeds that we hope will lead to the propagation of our approach not only to our three partners, but throughout the nation.

**Broader Impact.** Widespread adoption of the τέχνη approach will have a broad and positive impact on the size and competency of the computing workforce. It will attract more students to computing. It will attract better students to computing. It will motivate and thus retain the students that it attracts, and the students it produces will be well equipped to take on the challenges and opportunities provided by the rapidly evolving field of computing.

The Clemson graduate program in digital production arts that inspired the development of the τέχνη curriculum consistently has a significantly higher percentage of women and minorities than the graduate and undergraduate programs in computer science. Thus, an additional impact is that the τέχνη approach, with its emphasis on creative design, may attract more women and minorities into computing.

### D.2. Current State

The current two-year τέχνη curriculum relies on a careful selection of large-scale problems from the visual domain. We have taken a *constructivist* view in this design, but, as noted by Duffy and Cunningham [1], this term has come to encompass such a wide span of directions in education that further specification is essential. Our view is certainly Piagetian, sometimes termed *cognitive constructivism*, and draws directly from Piaget [2], Dewey [3], and Rousseau [4] in that fundamental tenets are these:

- Learning is an active process of constructing individual knowledge.
- Learning occurs when observations differ from expectations, and new mental models must be constructed to accommodate the differences.
- Teaching is the process of invoking and supporting these constructions.

#### D.2.1. Problem Selection

It is not surprising then that we use problem-based instruction as a vehicle, but our design differs from others in the depth and scope of the problems addressed. Fundamental tenets of our approach are that a visual problem domain will most quickly capture the attention and interest of students who have grown up in a society that is increasingly visually oriented, that a connection between scientific and artistic components will stimulate both deductive thought and creativity, and that toy, topic-driven problems are of limited value in effecting the principal desired accommodation, an ability to solve real problems. Thus the problems are large-scale, with one problem per semester. To avoid staleness and the temptation of students to recycle solutions, the details of the problem vary from semester to semester. In CS1 the problem is taken from the domain of transformations of two dimensional images, in CS2 ray tracing, and in CS3 reconstruction of

three dimensional surfaces from point cloud data. The problems are simple to describe but have non-trivial and open-ended solutions. A primary benefit of the class of problems is that none has a strictly "right" or "wrong" answer, and thus students must begin to develop non-trivial methods for evaluation of their own work.

Because the problems are large and open-ended, we do provide a conceptual framework within which the students explore and build. Thus our method is probably best characterized as constructivism with an objectivist scaffolding [5], or, to those who study epistemology, a naive retracing of first steps in the direction of Kant's transcendental logic [6].

In this context, with very large problems, we can also rely on the *cognitive apprenticeship*, a concept probably due to Resnick [7]. We contend that there is great value in observation of a master at work in problem solving. The process is the key. We thus encourage instructors to present solutions to problem components in a manner that is as close as possible to their own original solutions, including any and all missteps. Such solutions carry a vitality that is missing in solutions that have been cleaned and polished for presentation in more formal settings. The accomplished mathematician Wilhelm Stoll was once asked to explain how mathematicians translate their motivation into mathematical proof. He replied that a proof is motivation written backwards. We favor direct presentation of the motivation. Thus, while the approach is fundamentally constructivist, it does rely upon an objectivist scaffolding provided by the instructor.

### D.2.2. Language Selection

The focus of the τέχνη project has been on defining the introductory sequence in the new curriculum. Hereafter we will refer to these courses as CS1, CS2, and CS3. The programming languages of instruction for the courses were chosen carefully. We had to remain consistent with our constructivist design, with its roots in empiricism, but we also needed a tight integration with the semester-long problem in each course, so that the language provided a convenient vehicle for solution. We also sought a smooth, natural transition from each language to the next.

In all of our course design, we emphasize, even to a greater extent than does Resnick [7], the critical importance of appropriate mental models of complex systems. Early development of a mental model of computing, as described by the von Neumann architecture, is crucial to undergraduate student success. The attendant flexibility in response to unexpected situations cannot await post-graduate training. In this case, the use of a small, imperative programming language that is close to the machine itself is most conducive to this development, and so we use *C* in both CS1 and the first part of CS2. We are aware of arguments that advocate immersion of students in the object-oriented paradigm and use of an object-oriented language from the outset, but we reject those arguments on the same empiricist basis that society, decades ago, rejected the rationalists' "new math." Learners are simply unable to abstract details they have never seen and of which they are completely unaware. Learning naturally proceeds by accommodation from specific evidence and detailed observations to theoretical (operational) models.

The CS2 project is the design and implementation of a ray tracing system. Structure hierarchies of increasing specialization (e.g., generic object, plane, tiled plane) are used to motivate the concept of inheritance in a way that is tightly coupled to the machine model. When the analogous class structure is presented in the second half of the course, the students grasp what is actually going on "under the covers." Polymorphism is motivated by the use of function pointers. The generic object contains function pointers that return the ambient, diffuse, and specular reflectivity of the object. Specialized objects such as tiled or textured planes can override the default behavior by overwriting the default function pointers. In this way a student develops

a proper mental models of why polymorphism is a useful facility and how it might be implemented.

A strong argument can be made that the extreme flexibility of *C* can allow bad programming habits to develop, and we do not dispute this, but the principal argument against the use of *C* in a first course appears to be centered on its complexity of expression. Dingle and Zander [8] point to the classic, fast string copy as evidence:

```
while(*s++ = *t++); // tricky for CS1 students
```

Yet, if an accurate mental model of the machine is in place, is this really tricky? It is somewhat ironic that, in his January, 2005, advice column to computer science students [14], Joel Spolsky refers to the very same example, with a very different take, "I don't care how much you know about continuations and closures and exception handling: if you can't explain why "while(*s++=*t++);" copies a string, or if that isn't the most natural thing in the world to you, well, you're programming based on superstition, as far as I'm concerned: a medical doctor who doesn't know basic anatomy, ..."

### D.3. Implementation Plan

Consistent with the objectives of the CPATH EAE program there are three major components of the proposed research: evaluation; adoption; and extension. Each is discussed in detail in the following sections.

#### D.3.1. Evaluation and Assessment Plan

Our assessment of the τέχνη prototype course, CPSC 215, relied largely upon informal assessment mechanisms, primarily written comments in which students related their perceptions of the class environment [11]. The principal finding there was a heightened enthusiasm for computing among both students and instructors.

In the academic year 2005-06 we conducted a small, but relatively more formal assessment of the merits of the τέχνη approach to CS1 as compared to a more conventional topic-driven approach using Java as the introductory language. In the Fall semester of 2005, new students were randomly assigned to one of two sections of CS1. One section was taught using the τέχνη approach, and the other used a conventional, topic-driven approach. At the conclusion of the course, students answered a series of questions, some of which comprised an attitude survey and others of which comprised a skills test. Results of the attitude survey and the skills test are shown in Figure 1. The τέχνη section is shown in magenta and the Java in blue.

The attitudinal questions were:

- Do you feel the class made you more creative or better able to express you creativity?
- How would rate your knowledge of the {C|Java} programming language?
- Would you recommend CS1 to a friend or colleague?

The skills tests involved reading code, writing code, and understanding logical operators. The code reading question presented students with an implementation of insertion sort and asked for an explanation of what the code was doing. The code writing question asked students to provide code that would search for a specific value in an array. The logical operators question had five expressions composed of boolean variables and logical operators thereon. Each was to be labeled true or false, based on values assigned to the boolean variables.

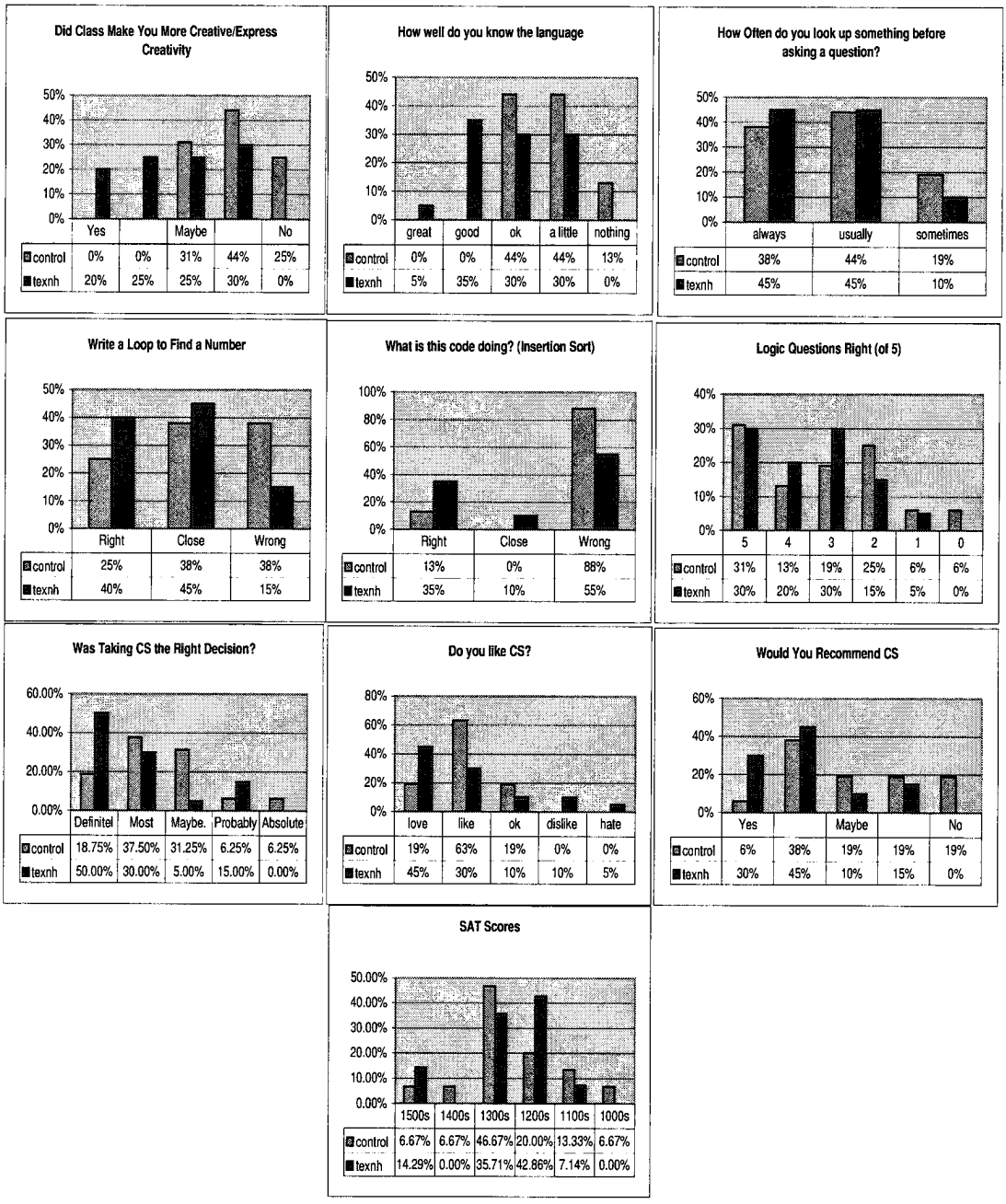


Figure 1: Assessment of Student Skills

The population sizes (16 and 20) were not quite large enough to justify t-tests for differences in means, so we used a Monte Carlo version of Fisher's permutation test [9]. We found significant (0.05 or better) differences on all three attitudinal questions and on the reading skills test. Although the mean values were also better for the τέχνη approach on the writing and logic skills tests, we could not declare a significant difference on either of those. A more detailed discussion is presented in [15].

**Proposed Research and Intellectual Merit.** The assessment component of the project is the one in which new knowledge will be developed. One component of this new knowledge will be the identification of assessment mechanisms that can address the difficult problem of measuring the effectiveness of constructivist approaches to learning. The second will be identification of characteristics of problem domains that appear to best promote constructivist learning.

We will perform a systematic and detailed assessment of our approach using both direct and indirect measures of student objectives and learning outcomes and to compare our approach with the traditional approach using those measures. Assessment is, in the most general constructivist case, a difficult issue, since the validity of an individual accommodation is difficult to judge with a common measure. Because problem-solving in new contexts is the key development, overlays of scaffolding and cognitive apprenticeship offer us some clear directions for the assessment task. We plan to define the (1) curriculum objectives by formalizing the career and professional accomplishments that the program is aimed to prepare the students to achieve, (2) learning outcomes (what students are expected to know and to do at the time of graduation from the program) that can be measured by identifying the performances required to meet the outcomes, and (3) exact processes that will collect, use and analyze data that can measure the student accomplishments. We will use both direct measures (direct examination of student knowledge and skills against measurable learning objectives) and indirect measures that ascertain the opinion or perception of the value of learning experiences.

We plan to use two approaches. Dynamic assessment [10] repeatedly presents, during the course of instruction, tasks that are just one step beyond existing competence and then provides individual assistance as needed to reach independent mastery. This is based on Vygotsky's zones of proximal development [12]. A zone is defined as the distance between the apprentice's actual development as measured by independent problem solving and his or her potential development as determined by problem solving under the guidance of a master.

The measure is thus the amount of additional scaffolding required, beyond that supplied as a starting foundation, to achieve an effective solution to a new problem. Consider an example from our CS2 course in which the semester-long problem is ray tracing. Many instances of ray-object intersection algorithms are required for interesting scenes. The instructor may present a ray-sphere intersection algorithm and then open investigation into ray-cylinder intersection, which is significantly more difficult to do with cylinders of general orientation. It is also possible to permit the students to select the new object to be modeled from a collection of quadric surfaces so that selection is then also part of the problem.

We propose to introduce more rigorous embedded assessment into the courses to measure the degree to which stated learning outcomes are being achieved and to further validate the empirical results observed through the informal assessments. An interesting alternative to this direct assessment is available from the study of educational environments. Walker and Fraser [13] observe that numerous studies report a strong correlation between traditional student outcomes (e.g. grades, test scores) and perceptions of classroom environments. The latter can be measured with unobtrusive and time-saving survey instruments. Walker and Fraser use factor analysis on field tests to develop a survey instrument of 34 ratings on six scales: instructor support; student interaction and collaboration; personal relevance; authentic learning; active learning; and

student autonomy. Their instrument was ostensibly targeted at distance education, but if we simply omit the six items in the category of student interaction and collaboration, which is consistent with our cognitive constructivist view, we obtain a factorially valid instrument to measure classroom environments of any type. Thus we plan to use the resulting 28-item survey, in conjunction with dynamic assessment to measure the effectiveness of each of the three courses now underway. We will then use the data provided by these assessment mechanisms to identify characteristics of problem domains that best promote learning.

### D.3.2. Adoption Plan

Major curriculum changes are not easy to effect. Nevertheless, during the past four years, PIs of this proposed project were successful in effecting a radical redesign of the first two years of the curricula of the three undergraduate degree programs offered by the Department of Computer Science at Clemson University. This success was achieved via an incremental approach that is summarized here.

#### D.3.2.1 Background

When the τέχνη project was funded in the summer of 2003, the undergraduate curriculum in Computer Science at Clemson University commenced with a typical three course, objects-first sequence in which the Java programming language was used. A fourth course CPSC 215, introduced the *C* language and procedural programming.

Although it was the vision of the τέχνη project to profoundly alter this situation, it should be emphasized that when the project began, the only commitment made by the department to the PIs was to allow the PIs to teach CPSC 215 in a manner consistent with the proposal for the duration of the project. Any other curriculum or course changes would be made only on the basis of *demonstrated success* in the prototype(s) and would require approval of the full faculty.

This situation made an incremental approach the only viable option, but in retrospect it was also clearly the best option. The resulting four-year plan provided adequate time to defuse some political issues, to design and refine new courses, to identify additional faculty who wished to participate, and to address scheduling issues associated with the transition.

CPSC 215 was chosen as the prototype course because of its focus on *C* and procedural programming, and ray tracing was selected as the problem. This course was offered both semesters of the academic years 2003-05 and 2004-05, by PIs Davis, Geist, and Westall. During this two year period, replacement courses for the existing CS1, CS2, and CS3 were also being designed.

Based upon student feedback and numerous examples in which students produced ray traced images that significantly exceeded requirements, the CPSC 215 experiment was judged successful by the faculty. During the academic year 2004-05, the faculty voted to allow trial sections of the new CS1 and CS2 courses. These were offered in parallel with sections of the pre-existing CS1 and CS2 in the academic year 2005-06. Based upon the success of these offerings, the faculty voted to adopt the τέχνη curriculum for the full first two years of all of its undergraduate degree programs beginning with the academic year 2006-07.

At the start of the project, there was clearly skepticism regarding the project among some of the faculty. Some of this was caused by the perception that if a faculty member was not "in graphics" it would take a huge amount of extra work to understand how to apply a Sobel filter to a *.ppm* image or to create a *.ppm* image with a ray tracing system. To demonstrate that this was a misperception and thus improve the likelihood of

obtaining the needed faculty buy-in, we used the following strategy.

- The first offering of each course was taught by a τέχνη PI who prepared a comprehensive set of course materials including lecture notes, example problems, and sample solutions.
- When a faculty member who was not a τέχνη PI was offering a τέχνη course for the first time, the faculty member was paired with a τέχνη PI who served as a mentor.
- In subsequent offerings of the course, the non-τέχνη faculty member was encouraged to put his or her own spin on the course and to mentor other faculty members.

We specifically seek to avoid casting the details of any specific course in stone. Such an approach would rapidly produce staleness of content (not to mention excessive use of "recycled projects" by the students). Nevertheless, we do wish to operate within a consistent framework. For example, a faculty member teaching CS2 should feel free to cast the model description language or the set of objects modeled in any way he or she wishes, but should not feel free to change the project from a ray tracer to an accounting or student records system.

#### D.3.2.2 Partner Universities

Two partners, UNC-Wilmington and Western Carolina University will participate with the Clemson PIs in both the Evaluation and Adoption components of the project. Each partner is a regional campus of the University of North Carolina system. The PIs at the partner universities are Professor Sridhar Narayan at UNC-Wilmington and Professors Mark Holliday and Bill Kreahling at Western Carolina University. All have a strong interest in undergraduate computer science education, and each has published papers in the area. Based upon our own experience at Clemson, we felt it was not feasible to require partners to commit to making major changes to their curricula in advance. Thus the partners will use the same prototype-based approach that was used successfully at Clemson.

#### D.3.2.3 Adoption Plan Details

Each partner has agreed to teach a single course for at least two years using the τέχνη approach. Partners will use resources provided by Clemson as a point of departure but are encouraged to refine and extend the the course as they see fit. All partners will apply common assessment mechanisms that are agreed upon during an initial kickoff meeting and updated prior to the second year during an annual review meeting. UNC-W will use a CS-1 type course that presently uses the *C* language and is taught to science and pre-engineering majors (but not computer science majors). Clemson's present CS1 will be used as a model. WCU will also use the ray tracing problem in a course that is offered to computer science majors who have had two semesters of programming experience in Java. The audience for this course will thus be the same as that of the CPSC 215 course at Clemson.

### D.3.3. Extension Plan

There are three ways in which we will extend the τέχνη approach. Partner UNC-W will extend it to a computing course that supports disciplines other than computer science. The Clemson PIs will extend the τέχνη approach to senior division courses and in so doing extend the problem domain beyond the purely visual.

The course offered by partner UNC-W will demonstrate that the τέχνη approach is well suited for computing courses that support other disciplines. In a multi-disciplinary environment such as the one at UNC-W, we believe that use of the visual domain will motivate students far better than do topic-driven problems or problems traditionally chosen from the business or educational domains.

The Clemson PIs will extend the τέχνη approach into both new and existing senior division courses. Courses and problem domains that are presently under consideration include:

- Parallel processing: radiosity modeling on the GPU.
- Operating systems: implementation of a graphics or audio device driver.
- Information and coding theory: analysis, encoding, and decoding of audio streams.
- Database management systems: design and implementation of a multimedia database.

Although the new database course is yet to be offered, a high level design is complete, and we use it to illustrate our design approach.

Students will be given the opportunity to implement an online multimedia database system, MyTube, a scaled-down version of the popular YouTube system. Content for the MyTube system will include text, images, video, and audio which will be provided by the students themselves. We believe that a project based upon a popular and culturally relevant system such as YouTube will strongly motivate students to acquire skills in database management systems and web technologies.

Design of the course begins with identifying expected learning outcomes. On completing the course the student should have the ability to: (1) apply conceptual modeling concepts to the design of database applications; (2) design and analyze the properties of a database schema expressed in the relational data model; (3) retrieve data from relational databases using industry standard query languages; (4) apply the basic concepts of query optimization; (5) construct a database using a commercial relational database product; and (6) design and implement web-based database retrieval systems. Implementation of the MyTube system will accomplish these objectives using a real-world problem with which students are familiar. The creative nature and degree of artistic expression in this project are not typically found in a traditional database courses and will motivate students to achieve at the highest level.

In the first phase of the MyTube project, students will identify system requirements by exploring the YouTube system. Students will use the Entity-Relationship (ER) model to complete a conceptual design of the MyTube database, fulfilling the first objective of a traditional database course. In the second phase, students will convert their conceptual designs into relational schemata, fulfilling the second objective. Students will next design the actual database tables for the MyTube system by using the MySQL database management system based on their own relational database schemata. With the database tables in place, students will be able to insert, delete, and update the database using any multimedia objects they desire. Students will then be given English queries with which they will write the corresponding SQL statements and execute the queries on their own databases. This phase of the project will accomplish the third and fifth objectives. Using queries created by students as examples, the instructor will analyze and discuss query optimization issues in class. Then, students will be assigned to optimize their own queries. These exercises will achieve the fourth and fifth objectives of a traditional database course.

The final phase of the project will require students to write a web-based interface for the MyTube system, fulfilling the sixth objective. The open source web page development language, PHP, will be used in conjunction with SQL to retrieve the data from the database. Students will apply data structures, such as linked lists, hash tables, and trees, combined with appropriate algorithms, such as quick sort and binary search, to manipulate the data retrieved from the database by SQL statements. With the completion of the semester-long MyTube project, students will have mastered essential theories, techniques, and skills of a traditional database course, while learning them in a culturally relevant and interesting way. In this approach, students will first learn foundational concepts, and use them to build a complex system in a constructivist manner. Visual feedback of intermediate results will allow students to detect problems more readily. Intentional learning will occur as students are motivated to explore additional topics through independent study.

### D.4. Collaboration plan

Before the start of the first semester of the proposed project, all participants will meet at Clemson University. The Clemson PIs will make presentations on Clemson's new four course sequence and demonstrate online resources that are available. Common assessment mechanisms to be implemented in the first year will be agreed upon. During the first semester of the project, one of the Clemson PIs will travel to each partner university and present a colloquium describing the history, vision, and objectives of the project. At the end of the first year, all participants will again meet at Clemson for a project review. Representatives of each participating school will present results of the first year's effort, and assessment mechanisms to be implemented during the second year will be agreed upon.

All partners in the project will maintain local web pages in which course materials are made available to the public. Regular communication by e-mail and telephone will be used to rapidly report significant successes or obstacles that are encountered.

### D.5. Evaluation and Dissemination

Evaluation and assessment mechanisms were discussed in detail in section D.3.1. Two primary approaches will be used for dissemination. PIs at all participating universities will prepare final reports at the conclusion of the project. These reports will be in the form of a paper suitable for submission to a national computer science education conference, (e.g. SIGCSE), and will assess their experiences and identify ways in which the τέχνη approach might be improved. During the project each PI who offers a new course will maintain a publicly available archive of course materials including lecture notes, assignments, and tests. These materials will facilitate experimentation with and/or adoption of the τέχνη approach on a national scale.

### D.6. PI Participation and Timeline

PI Westall will serve as project leader and serve as mentor to faculty in existing τέχνη courses. PIs Srimani and Holliday will lead the assessment effort in which all PIs and the postdoc will participate. PIs Geist, Davis, Duchowski, and Wang will develop the new courses at Clemson and serve as faculty mentors. PIs Narayan and Kreahling will have analogous roles at UNC-W and WCU. The postdoc will teach one τέχνη course each semester at Clemson.

- Year 1 -
  - Project planning meeting at Clemson
  - UNC-W, and WCU offer new courses. Clemson offers new database course.
  - Clemson designs two additional senior division courses
- Year 2 -
  - Project review meeting at Clemson
  - UNC-W, and WCU offer new courses. Clemson offers two additional senior division courses and designs another.
  - UNC-W, and WCU investigate use of τέχνη approach in additional courses.
- Year 3 -
  - All partners analyze assessment data and prepare final reports.
  - Clemson offers fourth senior division course.

**D.6. Results of Prior Support**

Co-PIs Kreahling, Narayan and Wang have not been supported by the NSF within the past five years.

**Timothy A. Davis**

Co-PI Davis has served as PI or co-PI on two funded NSF proposals in the past five years. They are:

1. τέχνη: *A New Approach to the B.A. Degree in Computer Science*, NSF (CISE/EIA), PI T. Davis, $330,000, July, 2003 - July, 2007.
2. *Shooting in 3D with the Zmini Camera*, NSF (CISE/RR), PI T. Davis, $40,000 August, 2004 - July, 2007, equipment, no faculty salary support.

**NSF Award 0305318, τέχνη:** *A New Approach to the B.A. Degree in Computer Science*, NSF Award 0305318 is most closely related to the current proposal. Results of this project have been presented in some detail in this proposal.

Seven journal or conference papers have been published concerning the continuing work of the τέχνη project. An additional paper will appear in this year's SIGCSE proceedings. The most relevant papers are listed below.

- Davis, T., Geist, R., Matzko, S., and Westall, J., "Course Development under τέχνη," *Proc. Eurographics 2004 Education Program*, Grenoble, France, August, 2004, pp. 23-27.
- Davis, T., Geist, R., Matzko, S., and Westall, J., 'Visual Learning through the τέχνη Project," *Eurographics/ACM SIGGRAPH Workshop on Computer Graphics Education (CGE'04)*, Hangzhou, China, June, 2004.
- Wang, S., Davis, T., Geist, R., Westall, J. and Kundert-Gibbs, J., "Digital Production Arts: Coming Soon to a College Near You!" *Proc. of the* $42^{nd}$ *Annual ACM SE Conf.*, Huntsville, Alabama, April, 2004, pp. 416 - 421.
- Davis, T., Geist, R., Matzko, S., and Westall, J., "τέχνη: A First Step," *Proc. of the ACM SIGCSE Technical Symp. on Computer Science Education (SIGCSE 2004)*, Norfolk, Virginia, March, 2004, pp 125 - 129.

**Andrew T. Duchowski**

Co-PI Duchowski has served as PI or Co-PI on four funded NSF proposals in the past five years. They are:

1. *Integrating Asynchronous Technology and Virtual Reality to Support Education in Aircraft Maintenance Technology Education*, NSF (ATE through Greenville Technical College), Grant ATE-0302780, PI C. Castle, $389,655, 2003–2007.
2. τέχνη*: A New Approach to the B.A. Degree in Computer Science*, NSF (CISE/EIA), Grant EI-0305318, PI T. Davis, $330,000, 2003–2006.
3. *Visual Deictic Reference in a Collaborative Virtual Environment for Visual Search Training*, NSF (CISE/ITR), Grant IIS-0217600, PI A. Duchowski, $313,361, 2002–2004.

4. *CAREER: Development of an Eye Tracking Education and Research Program at Clemson University*, NSF (CISE/HCI), Grant IIS-9984278, PI A. Duchowski, $212,022, 2000–2003.

Approximately 30 journal or conference papers or other presentations and 1 textbook have been published by Co-PI Duchowski with about 20 papers resulting directly from NSF awards. Of these, 5 papers most relevant to the current proposal have been selected (see Relevant Publications in Co-PI Duchowski's Biosketch). The 9984278 (CAREER) award (recently terminated) is related to this proposal since it involved pedagogical development of a research-based course on eye tracking. Award EI-0305318 is strongly related to this proposal since it established the foundation for curricular development.

The most relevant results stemming from award 9984278 are student-authored publications describing outcomes from semester-long projects performed in the eye tracking class. Six such reports have been published in the last 3 years (2 from the class of 2005, 3 from 2004, and 1 from 2003).

Results from award EI-0305318 have not been published by Co-PI Duchowski since his involvement occurred fairly late in the course of the grant. Co-PI Duchowski was involved in the extension of CPSC 212 Data Structures and Algorithms, which focused on a graphics-related problem-based approach. Evaluation of student performance in this variant of the course are ongoing.

**Robert M. Geist**

Co-PI Geist has served as PI or co-PI on four funded NSF proposals in the past five years. They are:

- τέχνη: *A New Approach to the B.A. Degree in Computer Science*, NSF (CISE/EIA), PI T. Davis, $330,000, July, 2003 - July, 2007.
- *Design and Implementation of a Graphics Supercomputer from Commodity Components*, NSF (CISE/ACI/ITR), PI R. Geist, $284,834, August, 2001 - July, 2005.
- *Center for Advanced Engineering Fibers and Films*, NSF (ENG/EEC/ERC), PI D. Edie, $16,571,478, August, 1998 - July, 2004.
- *Validated Modeling of Network Component Performance*, NSF (CISE/(I/U)CRC), PI J. Westall, $50,000, July, 2001 - June, 2004.

Two of these have a direct bearing on this proposal, **NSF Award 0305318**, τέχνη: *A New Approach to the B.A. Degree in Computer Science*, (see Co-PI Davis), and **NSF Award 0113139**, *Design and Implementation of a Graphics Supercomputer from Commodity Components*.

From NSF Award 0113139:

- Rasche, K., Geist, R., and Westall, J., "Detail Preserving Reproduction of Color Images for Monochromats and Dichromats," *IEEE Computer Graphics & Applications*, Special Issue on Smart Depiction for Visual Communication **25**:3 (2005), to appear.
- Geist, R., Martin, J., and Westall, J., "Small Aggregations of ON/OFF Traffic Sources," *Proc. IASTED Int. Conf. on Communication and Computer Networks*, Boston, Massachusetts, November, 2004, pp. 312-318.

- Van Pernis, A., Geist, R., and Rashe, K., "Global Diffuse Illumination for Image Sequences," Proc. IASTED Int. Conf. on Computer Graphics and Imaging (CGIM 2004), Kauai, Hawaii, August, 2004.
- Geist, R., Rasche, K., Westall, J., and Schalkoff, R., "Lattice-Boltzmann Lighting," Proc. Eurographics Symposium on Rendering 2004 ($15^{th}$ Eurographics Workshop on Rendering), Norrköping, Sweden, June, 2004.
- Geist, R., Rasche, K., Srivatsavai, R., and Westall, J., "A Distributed Rendering System for Scientific Visualization," *Proc. of the* $41^{st}$ *Annual ACM Southeast Conf.*, Savannah, Georgia, March, 2003, pp. 359 - 364.
- Rasche, K., Geist, R., and Westall, J. "Out of Order Rendering on Visualization Clusters," *Proc. IASTED Int. Conf. on Modeling and Simulation (MS 2003)*, Palm Springs, California, February, 2003, pp. 461 - 467.
- Geist, R., Rasche, K., and Westall, J., "An HSV Representation of Non-Newtonian, Lattice-Boltzmann Flows," *Proc. SPIE Conf. on Visualization and Data Analysis (VADA 2002)*, San Jose, California, January, 2002, pp. 246 - 258.

**NSF Award 0113139**

The goal of this project was the design and implementation of a *graphics supercomputer*, i.e., a computing system capable of providing real-time, photorealism on a scale large enough to be labeled "immersive," from off-the-shelf, commodity components. Hardware for the project was provided through a $1.3 million grant from the W.M. Keck Foundation.

The system comprises 265 rack-mounted nodes (PCs) connected by 100Mb Ethernet and Gb Ethernet through a dedicated Gb switch. A single control node activates 24 geometry nodes, each of which generates geometry for 9 rendering nodes. The 216 ($24 \times 9$) rendering nodes can collectively receive geometry at 21.6Gbps through the system switch. Each of the 24 display nodes receives pixel data from 9 rendering nodes through its gigabit NIC for display on an attached DLP projector. The 24 projectors display at 1024x768 pixels and are arranged in a 6x4 configuration. This yields a display of 6144x3072 pixels.

The system software is based on Linux, OpenGL, and Chromium. Linux kernel 2.4 runs on all nodes. The rendering application context is described, in Python script, as a directed graph of stream processing units (SPUs). Calls by the application to OpenGL are intercepted by Chromium and routed through the SPU graph. The system was successfully implemented and demonstrated to produce frame rates in excess of 30 fps.

## Pradip Srimani

Co-PI Srimani has served as PI or Co-PI on two funded NSF proposals in the past five years. They are: *ITR: Self-Stabilizing Networking Protocols for Distributed Systems*, #0218495, $394433.00, 8/15/02 - 8/15/07 (with S. T. Hedetniemi and D. P. Jacobs). The activity funded by this grant is ongoing. A number of self-stabilizing protocols for different communication primitives have been developed and work is on going on complexity analysis. The results have been reported in [25, 17, 19, 38, 29, 34, 28, 35, 31, 18, 23, 33, 21, 22, 40, 24]

**Pradip K. Srimani**, *Mobility Tolerant Adaptive Multicast Protocols for Ad Hoc Networks*, NSF Award ANI-0073409, $299,998, 8/15/00-7/31/04 (with S. K. S. Gupta). We have developed two distributed algorithms to maintain respectively the minimum weight spanning tree (MST) based multicast tree and the shortest path (SPST) multi-cast tree in a given ad hoc network for a given multi-cast group. We have also extended our leader election algorithm to wrapped butterfly networks. We have developed a new time complexity analysis of the algorithms in terms of the number of rounds needed for the algorithm to stabilize after a topology change, where a round is defined as a period of time in which each node in the system receives beacon messages from all its neighbors. The results have been reported in [16, 27, 30, 26, 37, 34, 35, 36, 32, 21, 39, 20]

**James M. Westall**

PI Westall has served as PI or co-PI on three funded NSF proposals in the past five years. They are:

- τέχνη: *A New Approach to the B.A. Degree in Computer Science*, NSF (CISE/EIA), PI T. Davis, $330,000, July, 2003 - July, 2006.
- *Design and Implementation of a Graphics Supercomputer from Commodity Components*, NSF (CISE/ACI/ITR), PI R. Geist, $284,834, August, 2001 - July, 2005.
- *Validated Modeling of Network Component Performance*, NSF (CISE/(I/U)CRC), PI J. Westall, $50,000, July, 2001 - June, 2004.

Two of these have a direct bearing on this proposal, **NSF Award 0305318**, τέχνη: *A New Approach to the B.A. Degree in Computer Science*, (See PI Davis for details). **NSF Award 0113139**, *Design and Implementation of a Graphics Supercomputer from Commodity Components*, (See PI Geist for details).

**Mark A. Holliday**

Co-PI Holliday has received six awards of funding from the NSF. Two of the six have are in the domain of computer science education, and one of the six has been within the last five years.

1. NSF DUE-0410667/DUE-0533334, "Introducting Grid Computing into the Undergraduate Curricula", 1 July 2004 to 30 June 2006 (with a no-cost extension to 30 June 2007), $100,000 (with Barry Wilkinson).

Approximately 15 refereed journal or conference papers have resulted from the six awards. Those most relevant to the current proposal have been selected are shown in Co-PI Holliday's Biosketch. A complete listing of the publications is available at http://cs.wcu.edu/ holliday/pubs.html.

The NSF award DUE-0410667/DUE-0533334 is most closely related to the current proposal. Award DUE-0410667/DUE-0533334 involved developing, using, and evaluating course materials for teaching a grid computing course using an actual grid with sites at multiple campuses and students at multiple campuses.

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[4] J.-J. Rousseau. *Émile (translated by B. Foxley).* Dutton, New York, 1955.

[5] P. McKenna and B. Laycock. Constructivist or instructivist: Pedagogical concepts practically applied to a computer learning environment. In *Proc. ITICSE '04*, pages 166–170, Leeds, UK, June 2004.

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[16] S. K. S. Gupta, A. Bouabdallah, and P. K. Srimani. Self-stabilizing protocol for shortest path tree for multicast routing in mobile networks. *Springer-Verlag Lecture Notes in Computer Science*, 1900:600–604, April 2000.

[17] Martin Gairing, Wayne Goddard, Stephen T. Hedetniemi, Petter Kristiansen, and Alice McRae. Distance-two information in self-stabilizing algorithms. *Parallel Processing Letters*. To Appear.

[18] Martin Gairing, Wayne Goddard, Stephen T. Hedetniemi, and David P. Jacobs. Self-stabilizing maximal $k$-dependent sets in linear time. *Parallel Processing Letters*, 14:75–82, 2004.

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## F. Biographical Sketches.

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### Education

NORTH CAROLINA STATE UNIVERSITY Ph.D. in Computer Science, 1998 (advisor: E. W. Davis)
UNIVERSITY OF VIRGINIA M.C.S. in Computer Science, 1989
COLLEGE OF WILLIAM AND MARY B.S. in Computer Science and Mathematics, 1987

### Academic Appointments

CLEMSON UNIVERSITY Associate Professor of Computer Science, 8/05–Present.
CLEMSON UNIVERSITY Assistant Professor of Computer Science, 8/99–Present.

### Honors and Awards

- Pixar Animation Award – Runner Up, Eurographics Animation Festival, 2005
- Outstanding Faculty Award, Computer Science African American Alliance, 2004
- Best Animation – Second Prize, Flicks on 66 Animation Festival, 2005
- Best Graduate Student Paper Award, ACM Southeast Conference, 1998
- Upsilon Pi Epsilon Honor Society in the Computing Sciences, 1994-1998

### Related Publications

- T. A. Davis, "Graphics-Based Learning in First-Year Computer Science," *Eurographics Education Program* (2006), Vienna, Austria, September 2006, (Best Paper).
- S. Matzko and T. A. Davis, "Using Graphics Research to Teach Freshman Computer Science," *SIGGRAPH Educator's Program* (2006), Boston, MA, July 2006.
- T. A. Davis and J. Kundert-Gibbs, "The Role of Computer Science in Digital Production Arts," *SIGCSE Bulletin* 38:3 (2006), pp. 73-77.
- T. Davis, R. Geist, S. Matzko, and J. Westall, "Course Development under τέχνη," *SIGGRAPH Educator's Program* (2006), Boston, MA, July 2006.
- T. Davis, R. Geist, S. Matzko, and J. Westall, "τέχνη: A First Step," *ACM SIGCSE Bulletin*, **36**:1 (2004), pp. 125-129.

### Other Publications

- A. G. Chalmers, T. A. Davis, and E. Reinhard (Eds.), *Practical Parallel Rendering,* A. K. Peters, MA, 2002.
- J. Kundert-Gibbs (Ed.), *Maya: Secrets of the Pros,*, "Distributed Rendering" chapter with J. Richards, SYBEX Inc., CA, 2002.
- T. A. Davis and E. W. Davis, "Exploiting Frame Coherence with the Temporal Depth Buffer in a Distributed Computing Environment," *Proceedings of the IEEE Parallel Visualization and Graphics Symposium 1999*, San Francisco, CA, October 1999.

- T. A. Davis and E. W. Davis, "A Parallel Frame Coherence Algorithm for Ray-Traced Animations," *Proceedings of the Second Eurographics Workshop on Parallel Graphics and Visualization*, Rennes, France, October 1998.
- T. A. Davis and E. W. Davis, "Rendering Computer Animations on a Network of Workstations," *Proceedings of the 1998 IEEE International Parallel Processing Symposium*, Orlando, FL, March 1998.

**Synergistic Activities**

- Director, Digital Production Arts Program, 2006
- Reviewer, Southeast Digital Animation Festival, 2003-2004
- Panelist, NSF Evaluation Panel for ITR Proposals, 2002
- Session Chair, ACM Southeast Conference, 2002
- Referee, SIGGRAPH Courses Program, 1999-2002

**Teaching Experience**

- CPSC 101 Computer Science I
- CPSC 102 Computer Science I
- CPSC 215 Tools and Techniques for Software Development
- CPSC 411/611 Virtual Reality Systems
- CPSC 801 An Intensive Introduction to Computer Science for MFAC
- CPSC 805 Advanced Computer Graphics
- CPSC 808 Computer Animation
- CPSC 951 Computer Graphics Seminar

**Graduate Students** (M.S. and M.F.A.)
Amit Barman, Jeremy Barron, Jennifer Brola, Subhash Daga, Stephen Ficklin, Matthew Hanna, Brad Hollister, Christopher Jesudurai Rebecca Johnson, Daniel Ott, Jin Pei, Nishanth Pendluru, Kenneth Pestka, Jacob Richards, Serenthia Ross, Samuel Sampson, Brian Sorge, Joshua Staples, Deborah Wright

**Collaborators and Other Affiliations**
Alan Chalmers and Erik Reinhard, University of Bristol, UK, co-editor on *Practical Parallel Rendering*, 2002; co-author on *Course: Practical Parallel Rendering*, SIGGRAPH 1999, 2001, 2002.

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**Education**

SIMON FRASER UNIVERSITY, B.S. in Computer Science, 1990
TEXAS A&M UNIVERSITY, Ph.D. in Computer Science, 1997 (advisor: B.H. McCormick)

**Academic Appointments**

CLEMSON UNIVERSITY, Associate Professor of Computer Science, 8/02–Present.
CLEMSON UNIVERSITY, Assistant Professor of Computer Science, 1/98–8/02.

**Honors and Awards**

Early Promotion (Associate Professor), Clemson University, 2002.
Award for Faculty Excellence, Clemson University Board of Trustees, 2001
Recognition of Service Award, ACM, 2000, 2002
Faculty Early Career Development (CAREER) Award, NSF, 2000–2003

**Related Publications**

1. Ashmore, M., Duchowski, A. T., Shoemaker, G., "Efficient Eye Pointing with a Fisheye Lens", in *Proc. GI '05*, CHCCS/ACM.
2. Sadasivan, S., Greenstein, J. S., Gramopadhye, A. K., and Duchowski, A. T. Use of Eye Movements as Feedforward Training for a Synthetic Aircraft Inspection Task, in *Proc. CHI '05*, ACM.
3. Duchowski, A. T., Cournia, N., Cumming, B., McCallum, D., Gramopadhye, A., Greenstein, J., Sadasivan, S., and Tyrrell, R. A., Visual Deictic Reference in a Collaborative Virtual Environment, in *Proc. ETRA '04*, ACM.
4. Duchowski, A. T., *Eye Tracking Methodology*, Springer-Verlag, London, UK, 2003.
5. Duchowski, A. T., A Breadth-First Survey of Eye Tracking Applications, *Behavior Research Methods, Instruments, & Computers (BRMIC)*, 34(4), November, 2002.

**Other Publications**

1. Baudisch, P., DeCarlo, D., Duchowski, A. T., and Geisler, W. S., Focusing on the Essential: Considering Attention in Display Design, *Comm. of the ACM*, 46(3), March 2003, ACM.
2. Duchowski, A. T., Medlin, E., Cournia, N., Murphy, H., Gramopadhye, A., Nair, S., Vora, J., Melloy, B. J., 3D Eye Movement Analysis, *Behavior Research Methods, Instruments, & Computers (BRMIC)*, 34(4), November, 2002.
3. Duchowski, A. T., Medlin, E., Gramopadhye, A. K., Melloy, B. J., and Nair, S., Binocular Eye Tracking in VR for Visual Inspection Training, in *Proc. VRST '01*, ACM.
4. Nair, S., Medlin, E., Vora, J., Gramopadhye, A. K., Duchowski, A. T., Melloy, B. J., and Kanki, B., Cognitive Feedback Training Using 3D Binocular Eye Tracker, in *Proc. HFES '01*, HFES.
5. Vora, J., Nair, S., Medlin, E., Gramopadhye, A. K., Duchowski, A. T., and Melloy, B. J., Using Virtual Reality to Improve Aircraft Inspection Performance: Presence and Performance Measurement Studies, in *Proc. HFES '01*, HFES.

**Synergistic Activities**

- Guest Editor, Computer Vision and Image Understanding (CVIU), *Special Issue on Eye Tracking*, 2004.
- General Chair, Eye Tracking Research & Applications Symposium, 2000, 2002, 2004.
- Course Organizer, ACM SIGGRAPH 2000, Course 05, *Eye-Based Interaction in Graphical Systems: Theory & Practice*, 2000

**Graduate Students** (M.S. and Ph.D.)
N. Cournia (Ph.D.), E. Medlin (M.S.), G. Marmitt (M.S.), H. Murphy (Ph.D.), V. Shivashankaraiah (M.S.), C. Tonkin (Ph.D.).

**Other Collaborators outside Clemson University (48 months)**
A. Amir (IBM Almaden), P. Baudisch (Microsoft Research), D. Beymer (IBM Almaden), A. Çöltekin (University of Zurich, Switzerland), D. DeCarlo (Purdue University), M. Flickner (IBM Almaden), D. Parkhurst (Iowa State University), Q. Ji (Rensselaer Polytechnic Institute), W. Geisler (University of Texas at Austin), P. Qvarfordt (FX Palo Alto Laboratory), K-J. Räihä (University of Tampere, Finland), G. Shoemaker (Idelix), R. Vertegaal (Queen's University), H. Wechsler (George Mason University), J. Wobbrock (University of Washington), S. Zhai (IBM Almaden).

**Professional Service and Activities**

- Guest Editor, Computer Vision and Image Understanding (CVIU), 2004
- Paper Reviewer, SIGCHI, 2004
- Paper and Course Reviewer, SIGGRAPH, 2004
- Reviewer, International Journal of Human-Computer Studies, 2003
- Reviewer (research grant proposals), Civilian Research & Development Foundation, 2003
- Paper Reviewer (tertiary), SIGGRAPH, 2003
- Reviewer, Web3D Symposium, 2002
- Reviewer, Research Grants Council of Hong Kong, research grant proposals, 2002
- Reviewer, Journal of Behavior Research Methods, Instruments, & Computers (BRMIC), 2002
- Reviewer, Eye Tracking Research & Applications (ETRA) Symposium, 2000, 2002, 2004
- Panelist, NSF, regular research proposals, 2000, 2001

**Professional Memberships**

- EuroGraphics, since 2001
- ACM SIGGRAPH, since 2001
- Association for Computing Machinery, ACM, since 1990
- Institute for Electronics and Electrical Engineers, IEEE, since 1990
- Society of Photo-Optical Instrumentation Engineers, SPIE, since 1990

**Teaching Experience**

- CPSC 215 Software Development
- CPSC 241 Data Structures & Algorithms (CS IV)
- CPSC 405/605 Introduction to Computer Graphics
- CPSC 805 Advanced Computer Graphics
- CPSC 412/612 Eye Tracking Methodology
- CPSC 414/614 Human Computer Interaction
- CPSC 808 Computer Animation
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**Education**

UNIVERSITY OF NOTRE DAME Ph.D. in Mathematics, 1974 (advisor: F.X. Connolly)
UNIVERSITY OF NOTRE DAME M.S. in Mathematics, 1973
DUKE UNIVERSITY M.A. in Computer Science, 1980
DUKE UNIVERSITY B.A. in Mathematics, 1970

**Academic Appointments**

CLEMSON UNIVERSITY Professor of Computer Science, 8/87–Present.
UNIVERSITY OF NEW MEXICO Visiting Professor of Computer Science, 1/02–5/02.
CLEMSON UNIVERSITY Associate Professor of Computer Science, 1/84–7/87.
DUKE UNIVERSITY Associate Professor of Computer Science, 7/83–12/83.
DUKE UNIVERSITY Assistant Professor of Computer Science, 1/81–6/83.
DUKE UNIVERSITY Research Associate in Computer Science, 7/80–12/80.
PEMBROKE STATE UNIVERSITY Associate Professor of Mathematics, 8/77–6/80.
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL Visiting Asst. Professor of Mathematics, 1/77–6/77.
PEMBROKE STATE UNIVERSITY Assistant Professor of Mathematics, 9/74–8/77.

**Honors and Awards**

B.A. degree Summa Cum Laude
Phi Beta Kappa, Pi Mu Epsilon, Phi Eta Sigma, Sigma Xi
IFIP WG 7.3, Computer Performance Modeling and Analysis
Julia Dale Prize in Mathematics, 1970
Best Paper, $2^{nd}$ Government Neural Networks Applications Workshop, 1991
Highest-rated Paper, $30^{th}$ ACM Southeast Conf., 1992
Sigma Xi Award for Excellence in Research, 1994
Faculty Award for Achievement in the Sciences, 1997
National Scholars Award of Distinction, 2005
Best Paper (Günther Enderle Award), Eurographics, 2005

**Related Publications**

- Davis, T., Geist, R., Matzko, S. and Westall, J., "τέχνη: Trial Phase for the New Curriculum," *Proc. of the ACM SIGCSE Technical Symp. on Computer Science Education (SIGCSE 2007)*, Covington, Kentucky, to appear.
- Rasche, K., Geist, R., and Westall, J., "Re-Coloring Images for Gamuts of Lower Dimension," *Computer Graphics Forum* **24**:3 (2005), pp. 423-432, *Award: Best Paper, Eurographics 05.*
- Rasche, K., Geist, R., and Westall, J., "Detail Preserving Reproduction of Color Images for Monochromats and Dichromats," *IEEE Computer Graphics & Applications*, Special Issue on Smart Depiction for Visual Communication **25**:3 (2005), pp. 22-30.
- Geist, R., Rasche, K., Westall, J., and Schalkoff, R., "Lattice-Boltzmann Lighting," *Rendering Techniques 2004 (Proc. Eurographics Symposium on Rendering)*, Norrköping, Sweden, June, 2004, pp. 355 - 362, 423.

- Davis, T., Geist, R., Matzko, S., and Westall, J., "τέχνη: A First Step," *ACM SIGCSE Bulletin*, **36**:1 (2004), pp. 125 - 129; also appears in: *Proc. of the ACM SIGCSE Technical Symp. on Computer Science Education (SIGCSE 2004)*, Norfolk, Virginia, March, 2004.

**Other Publications**

- Geist, R., and Westall, J., "Correlational and Distributional Effects in Network Traffic Models," *Performance Evaluation*, **44** (2001), pp. 121 - 138.
- Geist, R., "Performance Bounds for Modeling NUMA Architectures," *Information Processing Letters*, **63**:2 (1997), pp. 113 - 117.
- Geist, R., "A Four-Stage Model for Predicting Creep Behavior," *ASCE Journal of Engineering Mechanics*, **124**:1(1998) pp. 118 - 120.
- Tomek, L., Mainkar, V., Geist, R., and Trivedi, K.,"Reliability Modeling of Life-Critical, Real-Time Systems," *Proceedings of the IEEE*, **82** (1994), pp. 108-121.
- Geist, R., Reynolds, R., and Suggs, D., "A Markovian Framework for Digital Halftoning," *ACM Trans. on Graphics*, **12**(1993), pp. 136-159.

**Synergistic Activities**

- Co-founder (with S. T. Wang, Dept. of Art), *Master of Fine Arts in Digital Production Arts*, Clemson University graduate degree program, 1999.
- Editorial Board (Assoc. Ed.), *Performance Evaluation* (North-Holland), 1999 - 2004.
- Associate Editor, *The College Mathematics Journal*, 1984 - 1985.
- Program Chair and Proceedings Editor, $28^{th}$, $33^{rd}$, $38^{th}$ Annual ACM Southeast Conference, 1990, 1995, 2000.
- Program co-Chair and Proceedings Editor, $3^{rd}$ IEEE Int. Performance and Dependability Symp., 1998
- U.S. Patent #5638190, *Context Sensitive Color Quantization System and Method*, 1997.

**Graduate Students** (M.S., M.F.A, and Ph.D.)
K. L. Adams (Nvidia), R. A. Allen (Mercer Univ.), A. G. Arens (Siemens)[1], M. P. Beede[1], M. L. Brown, M. H. Bryant (Rhythm & Hues), M. K. Chetuparambil (IBM), D. E. Crane, W. G. Crosmun, R. A. Danforth (Corel), S. W. Daniel (NetworkAppliance), S. Divatia, C. L. Dove, J. S. Junkins (Intel), J. M. Hanks, F. J. Harris (Univ. Nevada, Reno), O. A. Heim (Intel), C. S. Marshall (Intel), J. W. McPherson (Microsoft), M. M. Ng, K. Paramsivam (Microsoft), E. L. Pittard, L. E. Postner (Nassau Comm. College), V. E. Rao, W. R. Reynolds[1], K. R. Rasche (DreamWorks Animation) C. G. Reynolds, J. L. Richards(AT&T), V. M. Sekhar (VMWare), R. S. Shore, A. B. Smith (Intel), J. R. Soukup (Industrial Light & Magic), W. T. Stinson (Tippett Studios), D. G. Suggs (NetworkAppliance)[1], D. Treglia (Electronic Arts), A. P. Van Pernis (In-Three)[1], D. H. Vernon (WareOnEarth), C. Watcharopas (Kasetsart Univ.), C. L. Wilson

**Other Collaborators outside Clemson University (48 months)**
E. Angel (University of New Mexico), B. Armour (Electronic Arts), R. Armstrong (MIT), G. Gajewski (SC Research Auth.), K. Herbst (Sony ImageWorks), D. Kekas (NC State Univ.), M. Lavine (MIT), U. Neumann (Univ. Southern California), A. J. Rindos (IBM), G. Rutledge (MIT), D. Seager (Sony ImageWorks), A. Sawchuk (Univ. Southern California), K. S. Trivedi (Duke University)

[1]denotes $1^{st}$ place winner, ACM SE Student Paper Competition

**Pradip K. Srimani, IEEE Fellow**

## Education:

1978 Ph. D. in Computer Sc., University of Calcutta, India.

1975 M.Tech. (Radiophysics & Electronics), University of Calcutta, India.

1973 B.Tech. (Radiophysics & Electronics), University of Calcutta, India.

1970 B.Sc.(Hons. in Physics), University of Calcutta, India.

## Recent Professional Experience:

8/2000–present Professor and Chair, Computer Science, Clemson University, South Carolina.

1/90–8/2000 **Professor**, Computer Science, Colorado State University, Ft. Collins, Colorado.

1/2000–5/2000 **CNRS Visiting Researcher**, Universite de Technologie de Compiegne, France.

7/87–12/89 Professor, Computer Science, Southern Illinois University, Carbondale, Illinois.

9/84–6/87 Associate Professor, Computer Science, Southern Illinois University, Carbondale, Illinois.

6/81–8/84 Assistant Professor of Computer Science and Head of Computer Center, Indian Institute of Management, Calcutta, India.

**Teaching:** System Modeling, Data Structures, Operating Systems, Distributed Systems, Parallel Algorithms, Algorithm Analysis, Compiler Design, Database Systems.

Supervised 4 PhD and 29 MS theses, served on additional 5 Ph.D. and 30 M.S. graduate committees.

**Names of thesis supervisees during last five years:** Y. Rouskov, M. Bahl, G. Antonoiu, W. Shi, K. Sinha, Z. Xu

**Names of Collaborators during the last five years:** B. B. Bhattacharya (ISI, Calcutta, India), B. P. Sinha (ISI, Calcutta, India), W. Najjar, S. K. Gupta, A. P. Jayasumana (CSU, Ft. Collins, Colorado), S. Latifi (University of Nevada), S. T. Hedetniemi, D. P. Jacobs, W. Goddard (Clemson), R. Sloan (U. of Illinois), D. Soldan (Kansas State).

## Publications:

**Five Selected Publications Closest to the Proposal:**

- Z. Xu and P.K. Srimani, An online distributed gossiping protocol for mobile networks, *Journal of Combinatorial Optimization*, Vol. 11, No. 1, pp. 87–97, 2006.

- W. Goddard, S. T. Hedetniemi, D. P. Jacobs and P. K. Srimani, Self-Stabilizing global optimization algorithms for large network graphs, *International Journal of Distributed Sensor Networks*, Volume 1, No. 3–4, pp. 329–344, 2005.
- S. K. S. Gupta, and P. K. Srimani, Self-Stabilizing Multicast Protocols for Ad Hoc Networks, *Journal of Parallel and Distributed Computing*, Vol. 63, pp. 87–96, January 2003.
- S. K. S. Gupta, and P. K. Srimani, Core-Based Tree with Forwarding Regions (CBT-FR); A Protocol for Reliable Multicasting in Mobile Ad Hoc Networks, *Journal of Parallel and Distributed Computing*, Vol. 61, No. 9, pp. 1249–1277, September 2001.
- D. Talia, M. Cannataro, and P. K. Srimani, Parallel data intensive computing in scientific and commercial applications", *Parallel Computing*, Vol. 28, No. 5, pp. 673–704, May 2002.

**Five Other Recent Significant Journal Publications:**

- S. K. S. Gupta, A. Kahol, S. Khurana, and P. K. Srimani, A Strategy to Manage Cache Consistency in a Disconnected Distributed Environment, *IEEE Transactions on Parallel and Distributed Systems*, Vol. 12, No. 7, pp. 686–700, July 2001.
- S. K. S. Gupta, and P. K. Srimani, Adaptive Core Selection and Migration Method for Multi-cast Routing in Mobile Ad Hoc Networks, *EEE Transactions on Parallel and Distributed Systems*, Vol. 14, pp. 27–38, January 2003.
- G. Antonoiu and P. K. Srimani, A Self-Stabilizing Distributed Algorithm to Find the Median of a Tree Graph. *Journal of Computer and System Sciences*, Vol. 58, pp. 215–221, 1999.
- S. Latifi and P. K. Srimani, Near-Optimal Broadcast in All-Port Wormhole-Routed Hypercube Using Error-Correcting Codes. *IEEE Transactions on Parallel and Distributed Systems*, Vol. 11, pp. 247–260, 2000.
- K. Fitzerald, S. Latifi and P. K. Srimani, Reliability modeling and assessment of the Star-Graph networks. *IEEE Transactions on Reliability*, Vol. 51, pp. 49–57, March 2002.

## Professional Affiliations:

IEEE Fellow, Member of ACM.

## Recent Synergistic Activities:

- Editor, *International Journal of High Performance Computing and Networking*, (2004 – ); *International Journal of Sensor Networks*, (2004 – )
- **Editor-in-Chief**, IEEE Computer Society Press, 1997 – 2000 .
- **Editor,** IEEE Software, 1993 – 1998.
- **Editor**, IEEE Transactions on Knowledge and Data Engineering, 1999 – 2002; Parallel Computing, 2001– .
- **Guest Editor,** IEEE Transactions on Software Engineering, Journal of Parallel Computing, IEEE Transactions on Computers, MONET, WINET, IEEE Computer.

**Zijun (James) Wang**

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Clemson, SC 29634-0974

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email: jzwang@cs.clemson.edu
url: www.cs.clemson.edu/~jzwang/

**Education**

UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA, B.S. in Computer Engineering, 1990
UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA, M.S. in Computer Science, 1993
UNIVERSITY OF CENTRAL FLORIDA, Ph.D. in Computer Science, 2001

**Academic Appointments**

CLEMSON UNIVERSITY, Assistant Professor of Computer Science, 8/02–Present.
UNIVERSITY OF CENTRAL FLORIDA, Adjunct Instructor of Computer Science, 8/01–5/02
UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA, Teaching & Research Assistant, Department of Computer Science, 9/90–7/93
HEFEI ASSOCIATE UNIVERSITY, Adjunct Lecturer, Summers 1989–1993

**Industrial Appointments**

VERITAS SOFTWARE CORP, HEATHROW, FL Senior Software Engineer, 02/99–08/02.
COMPUTER ASSOCIATE INTERNATIONAL, INC., ORLANDO, FL Software Engineer, Project Leader, 08/98–02/99
UNIDATA, INC., ORLANDO, FL Systems Engineer, Director of R&D, 08/95–08/98
INSTITUTE OF SIMULATION AND TRAINING (IST), ORLANDO, FL Assistant Researcher, Summers 05/94–08/95

**Related Publications**

- James Z. Wang and Philip S. Yu, "Fragmental Proxy Caching for Streaming Multimedia Objects," *IEEE Transactions on Multimedia* **9**:1 (2007), pp. 147–156.
- James Z. Wang and Daniel Lowhorn, "Proxy Caching for Wireless Multimedia Streaming," *IEEE WirelessCom 2005, Symposium on Multimedia over Wireless*, Vol. 2, pp. 1100–1105, June 2005.
- James Z. Wang and Ratan K. Guha, "A Novel Data Caching Scheme for Multimedia Servers," *The Scientific Journal of EUROSIM: Simulation Practice and Theory*, Volume 9, Numbers 3–5, pp. 193-213, April 2002.
- James Z. Wang and Ratan K. Guha, "Data Allocation Algorithms for Distributed Video Servers," *In Proceedings of ACM Multimedia*, pages 456–459, Marina del Rey, California, November 2000.
- Kien A. Hua, Wallapak Tavanapong, and James Z. Wang "2PSM: An Efficient Framework for Searching Video Information in a Limited-Bandwidth Environment," *ACM-Springer Multimedia Systems Journal*, Volume 7, Number 5, pages 396–408, September 1999.

**Other Publications**

- Feng Luo, James Z. Wang and Eric Promislow, "Exploring Local Community Structures in Large Networks", *IEEE/WIC/ACM International Conference on Web Intelligence (WI 2006)*, Hong Kong, China, December 2006. (Acceptance rate: 18%, 67/374).
- James Z. Wang, Rapeeporn Payattakool, Feng Luo, and Chin-Fu Chen, "Web-based Tools for Gene Comparison and Clustering," *2006 Computational Systems Bioinformatics Conference (CSB2006)*, Stanford, CA, August 14–18, 2006.
- James Z. Wang and Matti Vanninen, "Self-Configuration Protocols for P2P Networks", *Web Intelligence and Agent Systems: An International Journal*, Volume 4, No. 1, pp. 61–76, 2006.
- James Z. Wang and Farha Ali, "An Efficient Ontology Comparison Tool for Semantic Web Applications," *IEEE/WIC/ACM International Conference on Web Intelligence (WI 2005)*, Pages 372–378, September 2005. (Acceptance rate: 18%, 59/328).
- James Z. Wang and Ratan K. Guha, "Efficiently Allocating Video Data in Distributed Multimedia Applications," *Journal of Applied System Studies: Methodologies and Applications for Systems Approaches, Special issue on Distributed Multimedia System with Applications*, Volume 2, Number 3, November 2001.

**Teaching Experience**

Distributed and Network Programming; Database Management System Design; Multimedia Systems and Applications; Data Mining; C Programming Language.

**Students Graduated**

Akhil Aggarwal, Rashmy Appaneravanda, Vasanth Balasubramanian, Vipul Bhulawala, Jonathan Johnson, Navdeep Johar, Daniel Lowhorn, Ramya P. Mana, Sailesh Mishra, Soundara Murugesan, Mahender Nagireddy, Ankur Pal, Bhargavi Panjala, Rapeeporn Payattakool, Daniel Rich, Kishore Senji, Matti Vanninen.

**Graduate Students**

**PhD Students (3):** Farha Ali, Dheeraj Chahal , Zhidian Du.
**MS Students (3):** Jesse Freeman, Bhargavi Panjala, William Taylor

**Collaborators in Clemson University**

Emil Alexov, Chin-Fu Chen, Robert Geist, David Jacobs, Pradip K Srimani, and Mike Westall

**Collaborators outside Clemson University**

Ratan K. Guha (Ph.D. Dissertation Advisor, University of Central Florida)
Kien A. Hua (University of Central Florida)
Huabei Jiang (University of Florida)
Clifford Lyon (CNET)
Wallapak Tavanapong (Iowa State University)
Simon Sheu (National Tsing-Hua University, Taiwan)
Philip S. Yu (IBM T. J. Watson Research Center)
Junbiao Zhang (Thompson Multimedia)

**James M. Westall**

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**Education**

DAVIDSON COLLEGE B.S. in Mathematics, 1968
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL Ph.D. in Mathematics, 1973
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL M.S. in Computer Science, 1978

**Academic Appointments**

CLEMSON UNIVERSITY Professor of Computer Science, 8/94–Present.
CLEMSON UNIVERSITY Associate Professor of Computer Science, 8/80–8/94
CLEMSON UNIVERSITY Assistant Professor of Computer Science, 8/78–8/80
CLEMSON UNIVERSITY Assistant Professor of Mathematical Sciences, 8/74–8/78

**Related Publications**

- Rasche, K., Geist, R., and Westall, J., "Re-Coloring Images for Gamuts of Lower Dimension," *Computer Graphics Forum* **24**:3 (2005), pp. 423-432, *Award: Best Paper, Eurographics 05.*
- Rasche, K., Geist, R., and Westall, J., "Detail Preserving Reproduction of Color Images for Monochromats and Dichromats," *IEEE Computer Graphics & Applications*, Special Issue on Smart Depiction for Visual Communication **25**:3 (2005), pp. 22-30.
- Davis, T., Geist, R., Matzko, S., and Westall, J., "τέχνη: A First Step," *ACM SIGCSE Bulletin*, **36**:1 (2004), pp. 125 - 129; also appears in: *Proc. of the ACM SIGCSE Technical Symp. on Computer Science Education (SIGCSE 2004)*, Norfolk, Virginia, March, 2004.
- Davis, T., Geist, R., Matzko, S. and Westall, J. , "Course Development under τέχνη," *SIGGRAPH Educator's Program* (2006), Boston, MA, July 2006.
- Davis, T., Geist, R., Matzko, S., Westall, J., "Texnh: Trial Phase for the New Curriculum", in *Proc. of the 38h SIGCSE Technical Symposium on Computer Science Education*, (Covington, KY, Mar. 2007), to appear.

**Other Publications**

- Geist, R., Rasche, K., and Westall, J., "Out of Order Rendering on Visualization Clusters," *Proc. of the IASTED Intl. Conf. on MODELING and SIMULATION*, Palm Springs, CA, February, 2003, pp. 461-467.
- Geist, R., and Westall, J., "Fast and Accurate Synthesis of Correlated Processes by Pre-compensated Transfer of Correlation," *Proc. of Communication Networks and Distributed Systems Modeling and Simulation (CNDS 02)*, (San Antonio, TX, Jan 2002), pp. 11-17.
- Geist, R. and Westall J. "Correlational and Distributional Effects in Network Traffic Models", *Performance Evaluation*, **44**(1), 121-138 (2001).
- Geist, R., Hicks, J., Smotherman, M., and Westall, J., "Parallel Simulation of Petri Nets on Desktop PC Hardware," *Proc. of the 2005 Winter Simulation Conf. (WSC 2005)*, Orlando, Florida, December, 2005, pp. 374-383.

- Geist, R., Rasche, K., Westall, J., and Schalkoff, R., "Lattice-Boltzmann Lighting," *Rendering Techniques 2004 (Proc. Eurographics Symposium on Rendering)*, Norrköping, Sweden, June, 2004, pp. 355 - 362, 423.

**Synergistic Activities**

- Director of Graduate Affairs, Dept. of Computer Science, 1994-2004.
- Member of the Board of Directors, Digital Production Arts Program, 2000-present.

**Graduate Students** C. Zeringue, T. Ledford, R. Moss, M. Yang, D. Sikkema, M. Shuler, B. Starcher, S. Able, W. Hollis, J. Chern, J. Maybry, S. Palkar, L. Williams, B. Buddhavaparau, N. Deep, A. Sinha, S. Shrivastava, J. Baker, S. Moolky, T. Tatum, S. Bahadur, V. Ranjan, C. Freise, S. Hingorini, R. Bahukudumbi, N. Aerrabatu, H. Gilkey, M. Page, V. Kalyanakrishnan, A. Flower, S. Bhikshesvaran, S. Viswanathan, K. Spicer, I. Ahmed, V. Manan, V. Mamtani, V. Mamidi, C. Bhasin, H. Gangani, V. Sharma. M. Gokhale, A, Desai, V. Nagapraveen, H. Narendra, S. Pathak, P. Wells, N. Paul, R. Rameneni, T. Landry, K. Sethu, S. Vadhanam, S. Drachova, V. Polyboyina, A. Patil, R. Srivatsavai, V. Yalla, R. Bhat, R. Ligon

**Other Collaborators outside Clemson University**

- G. Gajewski, South Carolina Research Authority
- A. Rindos, IBM Corporation
- K. Trivedi, Duke University

**Teaching Experience**

- Mathematics: College Algebra and Trigonometry, Calculus I and II, Numerical Analysis I and II.
- Computer Science: Introduction to Programming, Data Structures, Peripherals and Files, Computer Systems, Computer Systems Performance Evaluation, Introduction to Computer Graphics, Online Systems, Assembly Language Programming, System Programming, Introduction to Operating Systems, Computer Networks(graduate), Systems Modeling(graduate), Internetworking(graduate), Case Study in Operating Systems(graduate), Advanced Operating Systems(graduate)

**Sridhar Narayan**

Department of Computer Science
601 South College Road
UNC-Wilmington
Wilmington, NC, 28403

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url: http://people.uncw.edu/narayans
email: narayans@uncw.edu

**Education**

IIT MADRAS, INDIA B. Tech. in Mechanical Engineering., 1983
CLEMSON UNIVERSITY, M.S. in Computer Science, 1990
CLEMSON UNIVERSITY, Ph.D. in Computer Science, 1993

**Academic Appointments**

UNC-WILMINGTON Associate Professor of Computer Science, 8/00–Present.
UNC-WILMINGTON Assistant Professor of Computer Science, 8/94–8/00.
CLEMSON UNIVERSITY Lecturer in Computer Science, 1/94–8/94

**Related Publications**

- Narayan, S. and Tompkins, J. "Using Robotics to Enhance Learning in Introductory Computer Science Courses," *Proceedings of the 41st ACM Southeast Conference (ACMSE'03),* (Savannah, GA), pp. 412-415, March 2003.
- Narayan, S. and Tagliarini, G., "Java RMI-based Approach for Web-enabling the ArcView GIS RPC Server", *Proceedings of the ESRI User Conference, July 2001.*

**Other Publications**

- Narayan, S., Tagliarini, G. and Page, E. , "Enhancing MLP Networks Using a Distributed Data Representation," *IEEE Transactions on Systems, Man and Cybernetics*, Vol. 26, No. 1, pp. 143-149, February 1996.
- Narayan. S, "The Generalized Sigmoid Activation Function: Competitive Supervised Learning," Information Sciences, Vol. 99, Issue 1-2, pp. 69-82, June 1997.
- Narayan, S. , "On the behavior of K-out-of-N Hopfield networks," *Intelligent Systems, Vol. 96, Issue 3-4, pp. 183-191, February 1997.*
- *Narayan, S. and Tagliarini, G., "An analysis of overfitting in MLP networks,"*, Proceedings of the IJCNN, *Montreal, 2005.*
- *White, C., Tagliarini, G. and Narayan, S., "An Algorithm for Swarm-based Color Image Segmentation,"* Proceedings of the IEEE SoutheastCon, *pp. 84-89, Greensboro, NC, April 5-7, 2004.*

**Synergistic Activities**

- In an effort to foster collaboration between computer science majors and students from other disciplines.
- Dr. Narayan initiated a collaborative software development effort between students in his Software Engineering course and students in a graduate class in Instructional Technology in the Watson School of Education at UNCW.

- Dr. Narayan initiated and supervised a software development effort by students in his Object Oriented Programming course, in which the students developed software for use by a local industrial partner. The success of the effort led to internship offers for the students in the following semester and a patent application for the product.
- He has developed software tools for Genetic Algorithms and Neural Networks for research purposes, which have also been successfully used by students in a course on Artificial Intelligence.
- Dr. Narayan has developed a Web-based tutorial for using the Stuttgart Neural Network Simulator, a popular, freeware neural network simulator.
- Narayan has developed and taught a short-course in Object Oriented Technology to members of the Information Technology Systems Division at UNCW.

**Other Collaborators outside UNC Wilmington**

- A. Abdelbar American University at Cairo (Egypt)
- R. Mathieu Saint Louis University

**Mark A. Holliday**

Department of Mathematics and Computer Science
426 Stillwell Building
Western Carolina University
Cullowhee, NC 28723

office phone: (828)227-3951
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url: www.cs.wcu.edu/~holliday/homepage.html

**Education**

UNIVERSITY OF VIRGINIA B.S. with High Honors in Mathematics and Economics, 1978
UNIVERSITY OF WISCONSIN AT MADISON M.S. in Computer Science, 1982
UNIVERSITY OF WISCONSIN AT MADISON Ph.D. in Computer Science, 1986

**Academic Appointments**

WESTERN CAROLINA UNIVERSITY Professor of Computer Science, 7/04–Present.
WESTERN CAROLINA UNIVERSITY Associate Professor of Computer Science, 1/94–7/04
DUKE UNIVERSITY Assistant Professor of Computer Science, 8/86–12/93

**Related Publications**

- Holliday, M. and Luginbuhl, D., "CS1 Assessment Using Memory Diagrams," *Proc. of the 35th ACM SIGCSE Technical Symposium (SIGCSE 2004)*, Norfolk, VA, March 2004, pp. 200-204.
- Holliday, M. and Luginbuhl, D., "Using Memory Diagrams When Teaching a Java-Based CS1," *Proc. of the 41st Annual ACM Southeast Conference (ACMSE 2003)*, Savannah, GA, March 2003, pp. 376-381.
- Holliday, M., "Animations of Computer Networking Concepts," *ACM Journal of Educational Resources in Computing*, volume 3, issue 2 (June 2003), pp. 1-26.
- Holliday, M., Wilkinson, B., House, J., Daoud, S., and Ferner, C., "A Geographically-Distributed, Assignment-Structured Undergraduate Grid Computing Course," *Proc. of the 36th ACM SIGCSE Technical Symposium (SIGCSE 2005)*, Saint Louis, MO, February, 2005, pp. 206-210.
- Wolffe, G., Yurcik, W., Osborne, H., and Holliday, M., "Teaching Computer Organization/Architecture With Limited Resources Using Simulators," *Proc. of the 33rd ACM SIGCSE Technical Symposium (SIGCSE 2002)*, Covington, KY, February 2002, pp. 176-180.

**Other Publications**

- Holliday, M., Wilkinson, B. and Ruff, J. "Using an End-to-End Demonstration in an Undergraduate Grid Computing Course," *Proc. of the 44th ACM Southeast Conference (ACMSE 2006)*, Melbourne, FL, March 2006.
- M.A. Holliday, "A Java Applet for Illustrating Internet Error Control", *Mathematics and Computer Education*, vol. 38, no. 3, Fall 2004, pp. 326-332.
- M.A. Holliday, "An Ethernet Java Applet for a Non-Major Course", *Mathematics and Computer Education*, vol. 31, no. 2, Spring 1997, pp. 158-166.
- Holliday, M., "System Calls and Interrupt Vectors in an Operating System Course," *Proc. of the 28th ACM SIGCSE Technical Symposium (SIGCSE 1997)*, San Jose, CA, February 1997, pp. 53-57.
- Holliday, M., "Incremental Game Development in an Introductory Programming Course", *Proc. of the 33rd ACM Southeast Conference*, pp. 170-175, Clemson, SC, March 1995.

Research journal papers published in IEEE Transactions on Computers, IEEE Transactions on Software Engineering, IEEE Transactions on Parallel and Distributed Systems, IEEE Spectrum, International Journal on Computer Simulation. Other refereed conference publications include SIGMEYRICS (1986, 1992) and ASPLOS (1989).

**Collaborators outside of Western Carolina University**

- M. Vernon, Univ. of Wisconsin—Madison
- C. Ellis, Duke University
- G. Byrd, North Carolina State University
- M. Stumm, Univ. of Toronto
- G. Wolffe, Grand Valley State Univ.
- W. Yurcik, NCSA, Univ. of Illinois—Urbana/Champaign
- H. Osborne, Univ. of Huddersfield (UK)
- D. Luginbuhl, Air Force Office of Scientific Research
- B. Wilkinson, Univ. of North Carolina at Charlotte
- C. Ferner, Univ. of North Carolina at Wilmington

**Teaching Experience**

- Introduction to Programming, Data Structures, Algorithms, Computer Architecture, Operating Systems (undergraduate and graduate), Computer Networks, Database Management Systems (undergraduate and graduate), Software Engineering, Logic for Computer Scientists, Computer System Performance Modeling (graduate)

**William C. Kreahling**

Department of Mathematics and Computer Science
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Western Carolina University
Cullowhee, NC 28723

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fax: (828)227-7240
email: wkreahling@email.wcu.edu
url: www.cs.wcu.edu/~wck

**Education**

PALM BEACH COMMUNITY COLLEGE A.A. in Business, 1992
APPALACHIAN STATE UNIVERSITY B.S. in Computer Science (Magna Cum Laude), 1996
APPALACHIAN STATE UNIVERSITY M.S. in Computer Science, 1999
FLORIDA STATE UNIVERSITY Ph.D. in Computer Science, 2005

**Academic Appointments**

WESTERN CAROLINA UNIVERSITY Assistant Professor of Computer Science, 8/05–Present.
APPALACHIAN STATE UNIVERSITY Adjunct Faculty Computer Science, 1999–2001.

**Publications**

- Holliday, M.A., and Kreahling W.C., "Information Security and Computer Systems: An Integrated Approach", *Information Security Curriculum Development Conference (InfoSecCD 2006)*, Kennesaw, GA, September 2006.
- Zhao, W., Kreahling, W., Whalley, D., Healy, C., and Mueller, F., "Improving WCET by Applying Worst-Case Path Optimizations", *Real-Time Systems*, October 2006, pp. 129-152.
- Kreahling, W., Hines, S., Whalley, D., and Tyson, G., "Reducing the Cost of Conditional Transfers of Control Using Comparison Specifications", *Proc. of the ACM conference of Languages, Compilers, and Tools for Embedded Systems*, June 2006, pp. 64-71.
- Kreahling, W., Whalley, D., Bailey, M., Yuan, X., Uh, G., and van Engelen, R., "Branch Elimination by Condition Merging", *Software Practice and Experience*, January 2005, pp. 51-74.
- Kreahling, W., Whalley, D., Bailey, M., Yuan, X., Uh, G., and van Engelen, R., "Branch Elimination via Multi-Variable Condition Merging", *Proc. of the European Conference on Parallel and Distributed Computing*, August 2003, pp. 261-270.
- Kreahling, W., and Norris, "Profile Assisted Register Allocation", *Proc. of the 2000 ACM Symposium on Applied Computing*, March 2000, pp. 774-781.

**Collaborators outside of Western Carolina University**

- C. Norris, Appalachian State University
- D. Whalley, Florida State University
- X. Yuan, Florida State University
- R. van Engelen, Florida State University
- G. Uh, Boise State University
- M. Bailey, Hamilton College, NY
- C. Healy, Furman University, SC

- F. Mueller, NC State University
- S. Hines, Florida State University

**Teaching Experience**

- Introduction to Programming (C, C++, Java), Introduction to Computer Organization Assembly Language, Organization of Programming Languages Theory of Computation, Shell Programming, Linux Tools,

# SUMMARY PROPOSAL BUDGET

YEAR 1

| ORGANIZATION | FOR NSF USE ONLY | | |
|---|---|---|---|
| **Clemson University** | PROPOSAL NO. | DURATION (months) Proposed | Granted |
| PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR | AWARD NO. | | |
| **James Westall** | | | |

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **James Westall - P.I.** | 0.00 | 0.00 | 1.00 | $ 11,908 | $ |
| 2. **Timothy A Davis - Co-P.I.** | 0.00 | 0.00 | 1.00 | 9,683 | |
| 3. **Andrew T Duchowski - Co-P.I.** | 0.00 | 0.00 | 1.00 | 10,652 | |
| 4. **Robert M Geist - Co-P.I.** | 0.00 | 0.00 | 1.00 | 14,102 | |
| 5. **Pradip Srimani - Co-P.I.** | 0.00 | 0.00 | 1.00 | 7,390 | |
| 6. ( **1** ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 1.00 | 9,436 | |
| 7. ( **6** ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 6.00 | 63,171 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( **1** ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 40,000 | |
| 2. ( **0** ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( **0** ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( **0** ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( **0** ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( **0** ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 103,171 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 26,652 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 129,823 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 15,000 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ **0** | | | | | |
| 2. TRAVEL **0** | | | | | |
| 3. SUBSISTENCE **0** | | | | | |
| 4. OTHER **0** | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( **0** ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 48,699 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 48,699 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 193,522 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **47% MTDC, PRED, 03, DHHS (Rate: 47.0000, Base: 168522)** | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 79,205 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 272,727 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 272,727 | $ |

M. COST SHARING PROPOSED LEVEL $ **0** | AGREED LEVEL IF DIFFERENT $

| PI/PD NAME | FOR NSF USE ONLY | | |
|---|---|---|---|
| **James Westall** | INDIRECT COST RATE VERIFICATION | | |
| ORG. REP. NAME* | Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | | |

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

# SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

| Other Senior Personnel<br>Name - Title | Cal | Acad | Sumr | Funds Requested |
|---|---|---|---|---|
| Wang, Zijun - Co-P.I. | 0.00 | 0.00 | 1.00 | 9436 |

# SUMMARY PROPOSAL BUDGET

YEAR 2

| FOR NSF USE ONLY | | |
|---|---|---|
| PROPOSAL NO. | DURATION (months) Proposed | Granted |
| AWARD NO. | | |

ORGANIZATION: **Clemson University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **James Westall**

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **James Westall - P.I.** | 0.00 | 0.00 | 0.50 | $ 6,133 | $ |
| 2. **Timothy A Davis - Co-P.I.** | 0.00 | 0.00 | 0.50 | 4,987 | |
| 3. **Andrew T Duchowski - Co-P.I.** | 0.00 | 0.00 | 0.50 | 5,486 | |
| 4. **Robert M Geist - Co-P.I.** | 0.00 | 0.00 | 0.50 | 7,263 | |
| 5. **Pradip Srimani - Co-P.I.** | 0.00 | 0.00 | 0.50 | 3,806 | |
| 6. ( 1 ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 0.50 | 4,856 | |
| 7. ( 6 ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 3.00 | 32,531 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( 0 ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 0 | |
| 2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( 0 ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( 0 ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( 0 ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 32,531 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 7,710 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 40,241 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 15,000 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ 0 | | | | | |
| 2. TRAVEL 0 | | | | | |
| 3. SUBSISTENCE 0 | | | | | |
| 4. OTHER 0 | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( 0 ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 48,699 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 48,699 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 103,940 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **47% MTDC, PRED, 03, DHHS (Rate: 47.0000, Base: 60684)** | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 28,521 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 132,461 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 132,461 | $ |

M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **James Westall**

ORG. REP. NAME*

| FOR NSF USE ONLY | | |
|---|---|---|
| INDIRECT COST RATE VERIFICATION | | |
| Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | |

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

# SUMMARY PROPOSAL BUDGET COMMENTS - Year 2

**Other Senior Personnel**

| Name - Title | Cal | Acad | Sumr | Funds Requested |
|---|---|---|---|---|
| Wang, Zijun - Co-P.I. | 0.00 | 0.00 | 0.50 | 4856 |

# SUMMARY PROPOSAL BUDGET

YEAR 3

| FOR NSF USE ONLY | | |
|---|---|---|
| PROPOSAL NO. | DURATION (months) Proposed | Granted |
| AWARD NO. | | |

ORGANIZATION: **Clemson University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **James Westall**

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **James Westall - P.I.** | 0.00 | 0.00 | 0.50 | $ 6,317 | $ |
| 2. **Timothy A Davis - Co-P.I.** | 0.00 | 0.00 | 0.50 | 5,137 | |
| 3. **Andrew T Duchowski - Co-P.I.** | 0.00 | 0.00 | 0.50 | 5,651 | |
| 4. **Robert M Geist - Co-P.I.** | 0.00 | 0.00 | 0.50 | 7,481 | |
| 5. **Pradip Srimani - Co-P.I.** | 0.00 | 0.00 | 0.50 | 3,920 | |
| 6. ( 1 ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 0.50 | 5,002 | |
| 7. ( 6 ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 3.00 | 33,508 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( 0 ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 0 | |
| 2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( 0 ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( 0 ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( 0 ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 33,508 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 7,941 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 41,449 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 15,000 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ 0 | | | | | |
| 2. TRAVEL 0 | | | | | |
| 3. SUBSISTENCE 0 | | | | | |
| 4. OTHER 0 | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( 0 ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 0 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 0 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 56,449 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **47% MTDC, PRED, 03, DHHS (Rate: 47.0000, Base: 56449)** | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 26,531 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 82,980 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 82,980 | $ |

M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **James Westall**

ORG. REP. NAME*

| FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION | | |
|---|---|---|
| Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | |



*ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

# SUMMARY PROPOSAL BUDGET COMMENTS - Year 3

| Other Senior Personnel<br>Name - Title | Cal | Acad | Sumr | Funds Requested |
|---|---|---|---|---|
| Wang, Zijun - Co-P.I. | 0.00 | 0.00 | 0.50 | 5002 |

# SUMMARY PROPOSAL BUDGET

Cumulative

| FOR NSF USE ONLY | | |
|---|---|---|
| PROPOSAL NO. | DURATION (months) Proposed | Granted |
| AWARD NO. | | |

ORGANIZATION: **Clemson University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **James Westall**

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. James Westall - P.I. | 0.00 | 0.00 | 2.00 | $ 24,358 | $ |
| 2. Timothy A Davis - Co-P.I. | 0.00 | 0.00 | 2.00 | 19,807 | |
| 3. Andrew T Duchowski - Co-P.I. | 0.00 | 0.00 | 2.00 | 21,789 | |
| 4. Robert M Geist - Co-P.I. | 0.00 | 0.00 | 2.00 | 28,846 | |
| 5. Pradip Srimani - Co-P.I. | 0.00 | 0.00 | 2.00 | 15,116 | |
| 6. ( 1 ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 2.00 | 19,294 | |
| 7. ( 6 ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 12.00 | 129,210 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( 1 ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 40,000 | |
| 2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( 0 ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( 0 ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( 0 ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 169,210 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 42,303 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 211,513 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 45,000 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ 0 | | | | | |
| 2. TRAVEL 0 | | | | | |
| 3. SUBSISTENCE 0 | | | | | |
| 4. OTHER 0 | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( 0 ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 97,398 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 97,398 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 353,911 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 134,257 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 488,168 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 488,168 | $ |

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **James Westall**

ORG. REP. NAME*

| FOR NSF USE ONLY | | |
|---|---|---|
| INDIRECT COST RATE VERIFICATION | | |
| Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | |

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

## G. Budget Justification.

Subcontractors are used because an important aspect of the EAE program is to propagate innovative curricula to other universities. PIs Narayan, Holliday, and Kreahling were specifically chosen each has a strong interest in undergraduate computer science education, and each has published papers in the area.

### G.1. PI Responsibilities.

PI Westall will serve as project leader and serve as mentor to faculty in existing τέχνη courses. PIs Srimani and Holliday will lead the assessment effort in which all PIs and the postdoc will participate. PIs Geist, Davis, Duchowski, and Wang will develop the new courses at Clemson and serve as faculty mentors. PIs Narayan and Kreahling will have analogous roles at UNC-W and WCU.

### G.2. Postdoc Responsibilities.

The research assistant who served in the original τέχνη project is completing her studies this year. She has agreed to remain at Clemson for an additional year to help maintain continuity. The postdoc will teach one τέχνη course each semester at Clemson, assist in the development of lab materials, and serve as a mentor to Clemson faculty.

### G.3. Travel.

Travel budgets for UNC-W and WCU will fund one trip to Clemson for the kickoff meeting and another for the annual review. They will also fund one trip to a regional conference and one to a national conference on computer science education of each of the partner PIs.

The Clemson travel budget will fund one trip to a national computer science education conference for the postdoc and a trip to a region conference and a national computer science education conference for each Clemson PI. The conference trips comprise an important component of our dissemination plan.

# SUMMARY PROPOSAL BUDGET YEAR 1

| FOR NSF USE ONLY | | |
|---|---|---|
| PROPOSAL NO. | DURATION (months) Proposed | Granted |
| AWARD NO. | | |

ORGANIZATION: **University of North Carolina at Wilmington**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Sridhar Narayan**

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **Sridhar Narayan - P.I.** | 0.00 | 0.00 | 1.00 | $ 9,762 | $ |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |
| 6. ( 0 ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 0.00 | 0 | |
| 7. ( 1 ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 1.00 | 9,762 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( 0 ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 0 | |
| 2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( 0 ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( 0 ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( 0 ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 9,762 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 2,538 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 12,300 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 1,400 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ 0 | | | | | |
| 2. TRAVEL 0 | | | | | |
| 3. SUBSISTENCE 0 | | | | | |
| 4. OTHER 0 | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( 0 ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 0 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 0 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 13,700 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **42.75% (Rate: 42.7500, Base: 13700)** | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 5,857 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 19,557 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 19,557 | $ |

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Sridhar Narayan**

ORG. REP. NAME*

| FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION | | |
|---|---|---|
| Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | |

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

# SUMMARY PROPOSAL BUDGET YEAR 2

| FOR NSF USE ONLY | | |
|---|---|---|
| PROPOSAL NO. | DURATION (months) Proposed | Granted |
| AWARD NO. | | |

ORGANIZATION: **University of North Carolina at Wilmington**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Sridhar Narayan**

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **Sridhar Narayan - P.I.** | 0.00 | 0.00 | 1.00 | $ 9,762 | $ |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |
| 6. ( 0 ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 0.00 | 0 | |
| 7. ( 1 ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 1.00 | 9,762 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( 0 ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 0 | |
| 2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( 0 ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( 0 ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( 0 ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 9,762 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 2,538 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 12,300 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 1,400 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ 0 | | | | | |
| 2. TRAVEL 0 | | | | | |
| 3. SUBSISTENCE 0 | | | | | |
| 4. OTHER 0 | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( 0 ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 0 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 0 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 13,700 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **42.75% (Rate: 42.7500, Base: 13700)** | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 5,857 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 19,557 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 19,557 | $ |

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Sridhar Narayan**

ORG. REP. NAME*

| FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION | | |
|---|---|---|
| Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | |

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

# SUMMARY PROPOSAL BUDGET

Cumulative

| ORGANIZATION | FOR NSF USE ONLY | | |
|---|---|---|---|
| **University of North Carolina at Wilmington** | PROPOSAL NO. | DURATION (months) Proposed | Granted |
| PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR | AWARD NO. | | |
| **Sridhar Narayan** | | | |

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **Sridhar Narayan - P.I.** | 0.00 | 0.00 | 2.00 | $ 19,524 | $ |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |
| 6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 0.00 | 0 | |
| 7. ( 1 ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 2.00 | 19,524 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( 0 ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 0 | |
| 2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( 0 ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( 0 ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( 0 ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 19,524 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 5,076 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 24,600 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 2,800 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ 0 | | | | | |
| 2. TRAVEL 0 | | | | | |
| 3. SUBSISTENCE 0 | | | | | |
| 4. OTHER 0 | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( 0 ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 0 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 0 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 27,400 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 11,714 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 39,114 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 39,114 | $ |
| M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $ | | | | |

| PI/PD NAME | FOR NSF USE ONLY | | |
|---|---|---|---|
| **Sridhar Narayan** | INDIRECT COST RATE VERIFICATION | | |
| ORG. REP. NAME* | Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | | |

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

# SUMMARY PROPOSAL BUDGET YEAR 1

| ORGANIZATION | FOR NSF USE ONLY | | |
|---|---|---|---|
| **Western Carolina University** | PROPOSAL NO. | DURATION (months) Proposed | Granted |
| PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR | AWARD NO. | | |
| **Mark Holliday** | | | |

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **Mark Holliday - P.I.** | 0.00 | 0.00 | 1.00 | $ 9,093 | $ |
| 2. **William Kreahling - Co-P.I.** | 0.00 | 0.00 | 1.00 | 6,846 | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |
| 6. ( 0 ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 0.00 | 0 | |
| 7. ( 2 ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 2.00 | 15,939 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( 0 ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 0 | |
| 2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( 0 ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( 0 ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( 0 ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 15,939 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 3,730 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 19,669 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 2,300 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ 0 | | | | | |
| 2. TRAVEL 0 | | | | | |
| 3. SUBSISTENCE 0 | | | | | |
| 4. OTHER 0 | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( 0 ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 0 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 0 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 21,969 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **45% of salaries (Rate: 45.0000, Base: 15939)** | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 7,173 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 29,142 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 29,142 | $ |

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

| PI/PD NAME | FOR NSF USE ONLY | | |
|---|---|---|---|
| **Mark Holliday** | INDIRECT COST RATE VERIFICATION | | |
| ORG. REP. NAME* | Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | | |

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

# SUMMARY PROPOSAL BUDGET

YEAR 2

| ORGANIZATION | FOR NSF USE ONLY | | |
|---|---|---|---|
| **Western Carolina University** | PROPOSAL NO. | DURATION (months) Proposed | Granted |
| PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR | AWARD NO. | | |
| **Mark Holliday** | | | |

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **Mark Holliday - P.I.** | 0.00 | 0.00 | 1.00 | $ 9,093 | $ |
| 2. **William Kreahling - Co-P.I.** | 0.00 | 0.00 | 1.00 | 6,846 | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |
| 6. ( 0 ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 0.00 | 0 | |
| 7. ( 2 ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 2.00 | 15,939 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( 0 ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 0 | |
| 2. ( 0 ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( 0 ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( 0 ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( 0 ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( 0 ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 15,939 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 3,730 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 19,669 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 2,300 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ 0 | | | | | |
| 2. TRAVEL 0 | | | | | |
| 3. SUBSISTENCE 0 | | | | | |
| 4. OTHER 0 | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( 0 ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 0 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 0 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 21,969 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **45% of salaries (Rate: 45.0000, Base: 15939)** | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 7,173 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 29,142 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 29,142 | $ |

M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $

| PI/PD NAME | FOR NSF USE ONLY | | |
|---|---|---|---|
| **Mark Holliday** | INDIRECT COST RATE VERIFICATION | | |
| ORG. REP. NAME* | Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | | |

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

# SUMMARY PROPOSAL BUDGET

Cumulative

| ORGANIZATION | FOR NSF USE ONLY | | |
|---|---|---|---|
| **Western Carolina University** | PROPOSAL NO. | DURATION (months) Proposed | Granted |
| PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR | AWARD NO. | | |
| **Mark Holliday** | | | |

| A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets) | NSF Funded Person-months CAL | ACAD | SUMR | Funds Requested By proposer | Funds granted by NSF (if different) |
|---|---|---|---|---|---|
| 1. **Mark Holliday - P.I.** | 0.00 | 0.00 | 2.00 | $ 18,186 | $ |
| 2. **William Kreahling - Co-P.I.** | 0.00 | 0.00 | 2.00 | 13,692 | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |
| 6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE) | 0.00 | 0.00 | 0.00 | 0 | |
| 7. ( **2** ) TOTAL SENIOR PERSONNEL (1 - 6) | 0.00 | 0.00 | 4.00 | 31,878 | |
| B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS) | | | | | |
| 1. ( **0** ) POST DOCTORAL ASSOCIATES | 0.00 | 0.00 | 0.00 | 0 | |
| 2. ( **0** ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.) | 0.00 | 0.00 | 0.00 | 0 | |
| 3. ( **0** ) GRADUATE STUDENTS | | | | 0 | |
| 4. ( **0** ) UNDERGRADUATE STUDENTS | | | | 0 | |
| 5. ( **0** ) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY) | | | | 0 | |
| 6. ( **0** ) OTHER | | | | 0 | |
| TOTAL SALARIES AND WAGES (A + B) | | | | 31,878 | |
| C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) | | | | 7,460 | |
| TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C) | | | | 39,338 | |
| D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) | | | | | |
| TOTAL EQUIPMENT | | | | 0 | |
| E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS) | | | | 4,600 | |
| 2. FOREIGN | | | | 0 | |
| F. PARTICIPANT SUPPORT COSTS | | | | | |
| 1. STIPENDS $ **0** | | | | | |
| 2. TRAVEL **0** | | | | | |
| 3. SUBSISTENCE **0** | | | | | |
| 4. OTHER **0** | | | | | |
| TOTAL NUMBER OF PARTICIPANTS ( **0** ) TOTAL PARTICIPANT COSTS | | | | 0 | |
| G. OTHER DIRECT COSTS | | | | | |
| 1. MATERIALS AND SUPPLIES | | | | 0 | |
| 2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION | | | | 0 | |
| 3. CONSULTANT SERVICES | | | | 0 | |
| 4. COMPUTER SERVICES | | | | 0 | |
| 5. SUBAWARDS | | | | 0 | |
| 6. OTHER | | | | 0 | |
| TOTAL OTHER DIRECT COSTS | | | | 0 | |
| H. TOTAL DIRECT COSTS (A THROUGH G) | | | | 43,938 | |
| I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) | | | | | |
| TOTAL INDIRECT COSTS (F&A) | | | | 14,346 | |
| J. TOTAL DIRECT AND INDIRECT COSTS (H + I) | | | | 58,284 | |
| K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.) | | | | 0 | |
| L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K) | | | | $ 58,284 | $ |

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

| PI/PD NAME | FOR NSF USE ONLY | | |
|---|---|---|---|
| **Mark Holliday** | INDIRECT COST RATE VERIFICATION | | |
| ORG. REP. NAME* | Date Checked | Date Of Rate Sheet | Initials - ORG |
| | | | |

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

**Budget and its Justification**

The subcontract to Clemson University is $ 20,000.

- Hemodynamic and oxygenation sensing module: **$ 4,000**

For hemodynamic and oxygenation sensing module and associated signal conditioning circuits

- Wireless radio modules: **$ 1,000**

For the proposed radio transceivers

- Fabrication of implantable wireless sensing device: **$ 4,000**

For custom circuit board fabrication, data acquisition board, and system integration

- Salary for two graduate students: **$ 10,000**

One for hemodynamic and oxygenation sensing module development and the other for wireless transmission design

- Miscellaneous cost: **$ 1,000**

Electrical wires, solders, testing instrumentation, and others

**Total: $ 20,000**

## H. Current and Pending Support.

### Timothy A. Davis

**Current Support (as PI or co-PI)**

- τέχνη: *A New Approach to the B.A. Degree in Computer Science*, $330,000, NSF (CISE/EIA), July, 2003 - July, 2007, 1 summer month/year.
- *Shooting in 3D with the Zmini Camera*, $40,000, NSF (CISE/RR), August, 2004 - July, 2007, equipment, no faculty salary support.

**Pending Support (as PI or co-PI)**

- *CRI: IAD A Multi-Teraflop System from a Small Array of Commodity, SIMD Processors*, NSF (CISE/CNS), $139,271, May, 2007 - May, 2010, equipment, no salary support.
- This proposal.

### Andrew T. Duchowski

**Current Support (as PI or co-PI)**

- *Graphics Research for Undergraduates*, NSF, $23,438, May, 2005 - June, 2007, 0 summer months/year.
- *ATE: Integrating Asynchronous Technology and Virtual Reality to Support Education in Aircraft Maintenance Technology Education*, NSF ATE through Greenville Technical College, $389,655, August, 2003 - August 2007, 1 summer month/year.

**Pending Support (as PI or co-PI)**

- *A Hand-Held Haptic Virutal Borescope Simulator for Visual Inspection and Maintenance Training*, ONR, $1,774,095, October, 2007 - September, 2012, 3 summer months/year.
- *Attentive User Interface Design for Human Attention Management*, ONR, $1,295,665, October, 2007 - September, 2012, 3 summer months/year.
- *Visual Inspection Laboratory (VisIns): Use of Interactive 3D Knowledge Objects to Promote Sudent Learnign in Aviation Maintenance Technology*, NSF through Greenville Technical College, $468,447, March, 2007 - March, 2010, 1 summer month/year.
- *Eyes Forward: Gaze-Guiding Science Education Software (Development, Evaluation, and Dissemination)* NSF CISE-IIS, $359,336 (est.), August, 2007 - September, 2010, 1 summer month/year.
- *HCC: Real-Time Re-Coloring of Images for Color-Deficient Observers* NSF (CISE/IIS), $302,012, August, 2007 - July, 2009, one summer month each year.
- This proposal.

## Robert M. Geist III

**Current Support (as PI or co-PI)**

- τέχνη*: A New Approach to the B.A. Degree in Computer Science*, $330,000, NSF (CISE/EIA), July, 2003 - July, 2007, 1 summer month/year.
- *Performance Evaluation of Large Disk Array Systems*, Network Appliance Corp., $32,000, January, 2005 - December, 2006, student fellowship, no faculty salary support.
- *Lattice-Boltzmann Modeling*, Nvidia Corp., $25,000, August, 2006 - August, 2007, Fellowship for Ph.D. student, no faculty salary support.

**Pending Support (as PI or co-PI)**

- *CRI: IAD A Multi-Teraflop System from a Small Array of Commodity, SIMD Processors* NSF (CISE/CNS), $139,271, May, 2007 - May, 2010, equipment, no faculty salary support.
- *Lending a Hand to Educators: Design and Assessment of an Instructional Tool for Creating Gesture-Enhanced, Animated Explanations in Low-Bandwidth Formats*, Microsoft Corp., $97,713, June, 2007 - May, 2009, one summer month.
- *HCC: Real-Time Re-Coloring of Images for Color-Deficient Observers*, NSF (CISE/IIS), $302,012, August, 2007 - July, 2009, one summer month each year.
- This proposal.

## Pradip K Srimani

**Current Support (as PI or co-PI)**

- *ITR: Self-Stabilizing Networking Protocols for Distributed Systems*, $94,433.00, NSF (CISE/CNS), August, 2002 - July, 2005, 1 summer month/year, no cost extension to July 2007.

**Pending Support (as PI or co-PI)**

- *CRI: IAD A Multi-Teraflop System from a Small Array of Commodity, SIMD Processors*, NSF (CISE/CNS), $139,271, May, 2007 - May, 2010, equipment, no salary support.
- *Self-Stabilizing Computing Models for Infrastructureless Networks*, NSF (CISE/CCF), $549,996.00, August 2007 - July 2010, 2 summer months/year.
- This proposal

## Zijun (James) Wang

**Current Support (as PI or co-PI)**

- *Web-based Distributed File Protection System*, America Management Group, Inc., PI, $16,199, 11/05–05/07.

**Pending Support (as PI or co-PI)**

- *Ontology-based Biological Knowledge Discovery*, NIH, PI, $317,928, 08/07–07/09, 1 month summer salary.
- This proposal.

**James M. Westall III**

**Current Support (as PI or co-PI)**

- *Performance Evaluation of Large Disk Array Systems*, Network Appliance Corp., $32,000, January, 2005 - December, 2006, student fellowship, no faculty salary support.
- Evaluating IEEE 802.16 Broadband Wireless as a Communications Infrastructure for Public Safety Activities, $150,000, National Institute of Justice, January 2006- January 2007, 1 summer month.

**Pending Support (as PI or co-PI)**

- *CRI: IAD A Multi-Teraflop System from a Small Array of Commodity, SIMD Processors*, NSF (CISE/CNS), $139,271, May, 2007 - May, 2010, equipment, no salary support.
- This proposal

**Sridhar Narayan**

**Current Support (as PI or co-PI)**

- None to list

**Pending Support (as PI or co-PI)**

- Using Squeak to Infuse Information Technology into the STEM Curriculum in Grades 7-12, Proposal # 0624615, NSF 05-621, Information Technology Experiences for Students and Teachers.
- This proposal.

# SUBCONTRACT DOCUMENTATION

THE UNIVERSITY OF NORTH CAROLINA AT WILMINGTON

January 18, 2007

Diane M. Meyers
Grants Administrator
College of Engineering and Sciences
113 Riggs Hall, Box 340901
Clemson, SC 29634-0901

SUBJECT: Letter of Support

The University of North Carolina Wilmington has reviewed the scope of work and budget for Dr. Sridhar Narayan's portion of the NSF proposal entitled "**TEXNH: Evaluation, Adoption, and Extension**" with James Westall, PI. If the proposal is funded, we agree to perform the scope of work within the requested budget to the best of our professional ability.

Please do not hesitate to contact me if I may provide further information. UNCW is pleased and excited to be a partner in this project.

Sincerely,

Pamela B. Whitlock
Director
Office of Sponsored Programs

cc: Dr. Sridhar Narayan

OFFICE OF SPONSORED PROGRAMS
601 SOUTH COLLEGE ROAD · WILMINGTON, NORTH CAROLINA 28403-5973 · 910-962-3810 · FAX 910-962-4011

Prof Sridhar Narayan, Co-PI, UNC-Wilmington

Scope of work:

The co-PI will attend a one-day kickoff meeting at Clemson University to be scheduled shortly after notice of award is received.

The co-PI will offer CSC 112 at least two times during first two years the project is active. The Co-PI will follow the general approach used by PI Westall in CPSC 101 at Clemson in Fall 2006 but is encouraged to refine and otherwise enhance the course as he sees fit.

The co-PI will participate in the development of common evaluation and assessment mechanisms and will implement them in the CSC 112 class.

The co-PI will place course materials that he develops in a publicly available collection on the Web.

The co-PI will attend a one-day project review meeting at Clemson after the first year of the project.

The co-PI will write a final report at the conclusion of the project. This report will assess his experience and attempt to identify ways in which the TEXNH approach may be broadened or strengthened. This report should be in a form suitable for submission to a national computer science education conference, (e.g. SIGCSE).

Based upon his experience with CS 112 the co-PI will endeavor to identify other courses in the UNC-W curriculum in which the problem based learning in visual or other non-traditional domains may be successfully implemented.

| Budget Spreadsheet | Year 1 | | | Year 2 | | | Year 3 | | | Comments and |
|---|---|---|---|---|---|---|---|---|---|---|
| Formula calculates perm. salaries at 4% increase annually | | | | | | | | | | |
| **Personnel** | **Effort** | **Base sal** | **Request** | **Effort** | **Base sal** | **Request** | **Effort** | **Base sal** | **Request** | |
| PI AY(enter annual salary and % of effort) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| PI Summer(enter #mos, base is 1/9 AY | 0 | 0 | 9762 | 0 | 0 | 9762 | 0 | 0 | 0 | |
| co-PI AY | | | 0 | | 0 | 0 | | 0 | 0 | |
| co-PI Summ | | | 0 | | 0 | 0 | | 0 | 0 | |
| Other sr. pers | | | | | | | | | | |
| | | | 0 | | 0 | 0 | | 0 | 0 | |
| | | | 0 | | 0 | 0 | | 0 | 0 | |
| | | | 0 | | 0 | 0 | | 0 | 0 | |
| ***TOT PERM*** | | | 9,762 | | | 9762 | | | 0 | |
| Grad stud 1 | | | 0 | | | 0 | | | 0 | |
| Grad stud 2 | | | 0 | | | 0 | | | 0 | |
| Grad stud 3 | | | 0 | | | 0 | | | 0 | |
| Under grad 1 | | | 0 | | | 0 | | | 0 | |
| Under grad 2 | | | 0 | | | 0 | | | 0 | |
| Undergrad 3 | | | 0 | | | 0 | | | 0 | |
| ***TOT Student*** | | | 0 | | | 0 | | | 0 | |
| Other | | | 0 | | | 0 | | | 0 | |
| **TOTAL Salary** | | | 9,762 | | | 9762 | | | 0 | |
| **Fringe** | | | | | | | | | | |
| Permanent | | | 2,538 | | | 2,538 | | | 0 | |
| Students | | | 0 | | | 0 | | | 0 | |
| Temporaries | | | 0 | | | 0 | | | 0 | |
| **TOTAL Fringe** | | | 2,538 | | | 2,538 | | | 0 | |
| **TOTAL Pers** | | | 12,300 | | | 12,300 | | | 0 | |
| **Equipment** | | | | | | | | | | |
| Item(s) | | | | | | | | | | |
| Item(s) | | | | | | | | | | |
| **TOTAL EQUIP** | | | 0 | | | 0 | | | 0 | |
| **Travel** | | | | | | | | | | |
| Trip 1 (Conference) | | | 1000 | | | 1000 | | | | |
| Trip 2 (Clemson) | | | 400 | | | 400 | | | | |
| **TOTAL Travel** | | | 1400 | | | 1400 | | | 0 | |
| **Part. Support** | | | | | | | | | | |
| Stipends | | | | | | | | | | |
| Travel | | | | | | | | | | |
| Subst. | | | | | | | | | | |
| Other | | | | | | | | | | |
| **TOTAL Part.** | | | 0 | | | 0 | | | 0 | |
| **Other dir costs** | | | | | | | | | | |
| Supplies | | | | | | | | | 0 | |
| Publication | | | | | | | | | 0 | |
| Consultants | | | | | | | | | 0 | |
| Subcontracts | | | | | | | | | 0 | |
| Current Svcs | | | | | | | | | 0 | |
| **TOTAL Other DC** | | | 0 | | | 0 | | | 0 | |
| **TOTAL DC** | | | 13,700 | | | 13,700 | | | 0 | |
| **IDC** | | | 5,857 | | | 5,857 | | | 0 | |
| **TOTAL REQ** | | | 19,557 | | | 19,557 | | | 0 | |

WESTERN
CAROLINA UNIVERSITY

RESEARCH AND GRADUATE STUDIES

January 22, 2007

Dianne M. Myers
Grants Administrator
113 Riggs Hall, Box 340901
Clemson University
Clemson, SC 29634-0901

Dear Ms. Myers:

Western Carolina University is pleased to support your proposal entitled, "TEXNH: Evaluation, Adoption, and Extension" for submission to the DOE NERI program.

Dr. Mark Holliday will serve as the Western Carolina University PI on the project for a period of three (3) years at a budget of $58,283.72. Western Carolina University agrees to use good faith effort to achieve the objectives outlined within the specified budget.

Technical questions regarding this proposal should be addressed to the PI at:

Mark Holliday
Western Carolina University
828.227.3951

In matters of an award, please contact the following:

Michelle Hargis, Ed.D
Director Research Administration
828.227.7212

Please do not hesitate to contact me at 828.227.7212 if I can be of assistance.

APPROVED:

Scott Higgins, Ed.D
Graduate Dean
Western Carolina University

440 HFR Administration Building
Cullowhee, NC 28723-9022
Office: (828) 227-7398
Fax: (828) 227-7480
Web: www.wcu.edu/rgs

# WCU Subcontract

## Personnel

Professor Mark Holliday and Professor William Kreahling will serve as co-PI's at Western Carolina University.

## Scope of work

- The co-PI's will attend a one-day kickoff meeting at Clemson University to be scheduled shortly after notice of award is received.
- The co-PI's will offer CS 361 at least two times during first two years the project is active. They will follow the general approach used by PI Westall in CPSC 215 at Clemson in Fall 2005 but are encouraged to refine and otherwise enhance the course as they see fit.
- The co-PI's will participate in the development of common evaluation and assessment mechanisms and will implement them in the CS 361 class.
- The co-PI's will place course materials that they develop in a publicly available collection on the Web.
- The co-PI's will attend a one-day project review meeting at Clemson after the first year of the project.
- The co-PI's will write a final report at the conclusion of the project. This report will assess their experience and attempt to identify ways in which the texnh approach may be broadened or strengthened. This report should be in a form suitable for submission to a national computer science education conference, (e.g. SIGCSE).
- Based upon their experiences with CS 361 the co-PI's will endeavor to identify other courses in their curriculum in which the problem based learning in visual or other non-traditional domains may be successfully implemented.

## WCU Budget

| *Category* | *Amount* |
|---|---|
| Four one-person-day trips to Clemson | $600 |
| Two conference trips | $2,000 4000 |
| One month summer support for Holliday | $9,093 18186 |
| Two months summer support for Kreahling | $13,692.22 (= 2 X $6846.11) |
| Fringe Benefits | $5,402.94 + 2182 + 124 7709 |
| Indirect Costs (45% of salaries, $22,785) | $10,253.25 14345 |
| Total: | 41,041.41 |



49463
14345
59808
44063
2278