10-29-2015

Understanding Student Motivation and Strategic Engagement in Computer Science and STEM Courses

Duane F. Shell
University of Nebraska - Lincoln, dshell2@unl.edu

Leen-Kiat Soh
University of Nebraska - Lincoln, lsoh2@unl.edu

Abstract for DBER Group Discussion on 2015-10-29

Presenter(s), Department(s):

Duane Shell, Research Professor
Department of Educational Psychology
University of Nebraska-Lincoln

Leen-Kiat Soh, Associate Professor
Department of Computer Science and Engineering
University of Nebraska-Lincoln

Title:
Understanding Student Motivation and Strategic Engagement in Computer Science and STEM Courses

Abstract:
Students' motivation and strategic engagement have been identified as playing crucial roles in their success in STEM and CS classes. Numerous motivational constructs have been identified including goals, instrumentality of the course, mindsets, emotional/affective reactions, and self-efficacy. These are thought to motivate students' to achieve and to drive the self-regulation and engagement necessary for student-centered learning. Despite sometimes lengthy histories of research in these constructs and behaviors, there are still many questions about how students are motivated in their courses and how they can become effective self-directed, engaged learners. This talk will discuss research findings from five years of classroom research in introductory computer science courses. We have employed comprehensive pre- and post-survey questionnaires assessing student motivation, affect, and strategic engagement and examined impacts on grades and learning and the dynamics of motivation change across the semester. Courses have included computer science majors as well as engineering and other STEM and non-STEM undergraduates. We will talk about our findings and discuss implications for CS and STEM teaching and instruction in the undergraduate classroom.

UNL DEBR GROUP'S STEM EDUCATION SEMINAR

Understanding Student Motivation and Strategic Engagement in Computer Science and STEM Courses

Duane F. Shell[1] and Leen-Kiat Soh[2]

[1] Department of Educational Psychology
[2] Department of Computer Science and Engineering

University of Nebraska, Lincoln, NE

** Special thanks to Melissa Hazley, Abe Flanigan, Markeya Peteranetz, L. Dee Miller, Vlad Chiriacescu, Adam Eck and all of the class instructors.*

OVERVIEW

Introduction | Motivation, self-regulation, and engagement

Measures and Methods | Research instruments, designs, and analyses

Results | Research studies over the past six years

Food for Thought | Implications of findings for student motivation and engagement

INTRODUCTION | MOTIVATION

Future Time Perspective (FTP) [Husman; Lens]

- *FTP Connectedness*: Refers to the general ability to make connections between present activities and some future goal. Specifically, in our studies to make connections between the present and future CAREER goals.
- *Perceived Instrumentality Endogenous*: Reflects instrumentality for personally meaningful future goals and outcomes.
- *Perceived Instrumentality Exogenous*: Reflects a utilitarian connection between task results and future outcomes.

Self-Efficacy [Bandura]

- *Confidence in one's capability of doing a behavior or skill.*

INTRODUCTION | MOTIVATION

Classroom Goal orientation [Dweck; Elliot; Shell]

Learning

- *Approach*: Goals are directed at learning new knowledge or gaining competence consistent with most past formulations of learning or mastery goals.
- *Avoid*: Goals reflect an active desire to not learn material or take anything away from the course. A student who does not care about a course might set a goal to just complete course assignments without retaining any of the course content.

Performance

- *Approach*: Goals reflect a desire to obtain favorable judgments of one's abilities by others or perform better than others in the class.
- *Avoid*: Goals reflect the desire to avoid negative judgments of one's ability or do worse relative to others in the class.

Task (Work)

- *Approach*: Goals reflect wanting to perform a task well or achieve to a high level.
- *Avoid*: Goals reflect a desire to get through the class with as little time and effort as possible.

INTRODUCTION | MOTIVATION

Implicit belief theory [Dweck]

- *Incremental*: Believe that intelligence is malleable or changeable through learning.
- *Entity*: Believe that intelligence is fixed and unchanging.

INTRODUCTION | STRATEGIC SELF-REGULATION

General Metacognitive Self-Regulation [Pressley; Weinstein; Pintrich]

- *Planning*
- *Monitoring*
- *Use of Learning strategies*

Knowledge Building [Bereiter; Scardamalia]

- *Connection of new knowledge to existing knowledge*
- *Personally meaningful learning*
- *Production rather than reproduction of knowledge*

Lack of Regulation [Dweck; Vermunt; Shell]

- *Confusion*
- *Difficulty studying effectively*
- *Need help and support*

INTRODUCTION | ENGAGEMENT

- **Question asking**
  - *High*: Questions to advance personal knowledge growth, deeply understand the material, satisfy curiosity.
  - *Low*: Questions to find right answers, find out what instructor wants, clarify rote facts.
- **Study time**
  - *Hours per week study for class*.
- **Perceived study effort**
  - *Study more, same, or less than other students in the class*.

INTRODUCTION | CLASSROOM PERCEPTIONS

Collaborative Learning

- *Students work collaboratively on assignments*
- *Students share knowledge*

Teacher Directedness

- *Instructor leads class*
- *Instructor identifies information that is important*

Affect/Emotion

- *Positive (e.g., excited, inspired, determined)*
- *Negative (e.g., nervous, distressed, upset)*

MEASURES | MOTIVATION

Self-Efficacy

Students were asked to rate their confidence in their knowledge of 12 computational thinking and CS topics with emphasis on application in their chosen field and enhancing creativity in their field. Scale is 0-100.

- Your ability to use computational algorithms to solve problems in your field
- Your ability to conceptualize data in your field in ways that can be analyzed computationally
- Your ability to think of novel ways of doing things in your field

MEASURES | MOTIVATION

Goal Orientation-Classroom Goal Orientation Scale [Shell]

Learning

- *Approach*: Learning new knowledge or skills in the class just for the sake of learning them. Really understanding the class material.
- *Avoid*: Remembering material long enough to get through the tests after which you can forget about it; Getting this course done even though you don't care about the content.

Performance

- *Approach*: Doing better than the other students in the class on tests and assignments; Impressing the teacher/instructor with your performance.
- *Avoid*: Keeping others from thinking you are dumb; Avoiding looking like you don't understand the class material.

Task (Work)

- *Approach*: Doing my best on course assignments and tests; Getting a good grade in the class.
- *Avoid*: Getting through the course with the least amount of time and effort; Getting a passing grade with as little studying as possible.

MEASURES | MOTIVATION

Goal Orientation-Classroom Goal Orientation Scale [Shell]

- Students rate goals on a 5-point Likert scale from 1 (*very unimportant*) to 5 (*very important*).
- Scores are computed as the mean score of the items in each scale.
- There is a three-item per scale long version and a two-item per scale shortened version.
- Reliability equivalent for 3- and 2-item scales.

MEASURES | MOTIVATION

Future Time Perspective Scale [Husman & Shell]

Career Connectedness Scale

- One should be taking steps today to help realize future career goals.
- What will happen in the future in my career is an important consideration in deciding what action to take now.

- **Students rate goals on a 5-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*).**
- **Scores are computed as the mean score of the items in each scale with negative items reverse scored.**

MEASURES | MOTIVATION

Perceptions of Instrumentality Scale [Husman & Hilpert]

- **Endogenous instrumentality**
  - I will use the information I learn in this CS1 class in the future.
  - What I learn in this CS1 will be important for my future occupational success.

- **Exogenous instrumentality**
  - The only thing useful to me in this class is the grade I get.
  - The only aspect of this class that will matter after graduation is my grade.

MEASURES | MOTIVATION

Perceptions of Instrumentality Scale [Husman & Hilpert]

- Students indicate their agreement with each question using a 5-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*).
- Endogenous and exogenous scale scores are computed as the mean of the items in each scale.
- There is a 4-item per scale long version and a 3-item per scale shortened version.
- Reliability equivalent for 4- and 3-item scales.

MEASURES | MOTIVATION

Implicit Theories of Intelligence Scale [Dweck]

- *Incremental*: No matter who you are, you can significantly change your intelligence level.
- *Entity*: Your intelligence is something about you that you can't change very much.

- **Students indicate their agreement with each question using a 6-point Likert scale from 1 (*strongly disagree*) to 6 (*strongly agree*).**
- **Incremental and Entity scale scores are computed as the mean of the items in each scale.**
- **There is a 4-item per scale long version and a 3-item per scale shortened version.**
- **Reliability equivalent for 4- and 3-item scales.**

MEASURES | SPOCK

Student Perceptions of Classroom Knowledge Building (SPOCK) [Shell and others]

- **Students indicate how frequently they think the activities described in each of the statements occurred in their course on a 5-point Likert scale:**
  - 1 - Almost never - Occurred on a very rare occasion or not at all.
  - 2 - Seldom - Did not occur often: occurred about ¼ of the time.
  - 3 - Sometimes - Occurred about half of the time.
  - 4 - Often - Occurred frequently: occurred about ¾ of the time.
  - 5 - Almost always -Usually or always occurred: on a rare occasion it may not have occurred.
- **There is a 50-item long scale, a 2- item reduced scale, and a 21-item short scale.**
- **Scale scores are computed as the mean of the items in each scale.**
- **All versions have equivalent reliability.**

MEASURES | STRATEGIC SELF-REGULATION

Strategic Self-Regulation Measures all SPOCK

Metacognitive self-regulation

- In this class, I tried to determine the best approach for studying each assignment.
- In this class, I tried to monitor my progress when I studied.

Knowledge Building

- In this class, I tried to examine what I was learning in depth.
- As I studied a topic in this class, I tried to consider how the topic related to other things I know about.

Lack of Regulation

- In this class, I couldn't figure out how I should study the material.
- In this class, I relied on someone else to tell me what to do.

MEASURES | ENGAGEMENT

Engagement Measures from SPOCK

Question asking

- *High level*: In this class, I asked questions to more fully understand the topics we were learning.
- *Low level*: In this class, I asked questions so that I could find out what information the instructor thought was important.

MEASURES | ENGAGEMENT

Please indicate the average number of hours per week you spend studying for YOUR CLASS by circling one of the following.

1.=Less than 2 hours.
2.=2 to 4 hours.
3.=4 to 6 hours.
4.=6 to 8 hours.
5.=8 to 10 hours.
6.=10 to 12 hours.
7.=over 12 hours.

Please indicate which of the following best describes your own perception of the effort you put forth studying for YOUR CLASS by circling one of the following.

1. = I put forth much less effort studying than most students.
2. = I put forth somewhat less effort studying than most students.
3. = I put forth about the same effort studying as most students.
4. = I put forth somewhat more effort studying than other students.
5. = I put forth much more effort studying than other students.

.

MEASURES | CLASS PERCEPTIONS

Class Perception Measures from SPOCK

Collaborative Learning

- *In this class, my classmates and I actively worked together to complete assignments.*
- *In this class, my classmates and I actively worked together to help each other understand the material.*

.

Teacher Directedness

- *In this class, the instructor told us what the important information was.*
- *In this class, the instructor focused on getting us to learn the right answers to questions.*

MEASURES | CLASS PERCEPTIONS

Positive and Negative Affect Scale (PANAS) [Watson & Tellegen]

- **Students indicate how indicates how often they have experienced each particular emotion in their class on a 5-point Likert scale:**
  - 1 – A few times or not at all.
  - 2 – Occasionally, 25% of the time.
  - 3 - Quite often, 50% of the time.
  - 4 – Very Often, 75% of the time.
  - 5 – Most of the time, 80-100% of the time.
- **There is a 20-item long scale and 12-item reduced scale.**
- **Scale scores are computed as the mean of the items in each scale.**
- **All versions have equivalent reliability.**

MEASURES | CLASS PERCEPTIONS

Positive and Negative Affect Scale (PANAS) [Watson & Tellegen]

- **Positive emotions:**
  - interested.
  - excited.
  - inspired.
  - proud.

- **Negative emotions:**
  - upset.
  - frustrated.
  - distressed.
  - nervous.

MEASURES | ACHIEVEMENT

- **Course grade (0-4.0). At times *Z*-score standardized.**

- **Computational thinking knowledge test developed by CSCE faculty. The test containes 13 conceptual and problem-solving questions for the core computational thinking content common to all CS-1 classes. The coefficient alpha reliability estimates are .76-.78.**

RESULTS | ACHIEVEMENT

- Course grades and retention of course content are typically only moderately associated (r = .16 to r = .35 across studies and semesters).

- Suggests that students can achieve high grades without necessarily retaining much of the information from the course.

RESULTS | GENERAL ASSOCIATIONS

Variable			Course Grade	Knowledge Test
	M	*SD*	*r*	*r*
SPOCK Self-Regulation	3.30	.74	.220**	.206**
SPOCK Knowledge Building	3.10	.84	.255**	.135*
SPOCK Lack of Regulation	2.82	.78	-.249**	-.305**
SPOCK Question Asking Low	2.88	.93	.140	.127
SPOCK Question Asking High	2.85	.98	.103	.061
Study time	3.19	1.55	.001	.144*
Study effort	3.05	.92	.147*	.071

RESULTS | GENERAL ASSOCIATIONS

Variable			Course Grade	Knowledge Test
	M	*SD*	*r*	*r*
GO Performance Approach	3.01	.94	.118	.120
GO Performance Avoid	2.70	1.03	−.178*	−.005
GO Learning Approach	3.99	.90	.197*	.211**
GO Learning Avoid	2.62	1.03	−.146*	−.171*
GO Task Approach	4.25	.93	.176*	.270**
GO Task Avoid	2.58	.99	.023	−.122
PI Endogenous	3.71	.99	.217*	.322**
PI Exogenous	2.26	1.03	−.258**	−.337**
Positive Affect	3.10	.84	.252**	.269**
Negative Affect	2.10	.79	−.407**	−.213**
Incremental Belief	4.19	1.12	−.136	−.057
Entity Belief	2.67	1.15	.051	.087

RESULTS | GENERAL ASSOCIATIONS

Variable	Self-Reg. Strategy	Knowledge Building	Lack of Reg.	Study Time	Study Effort
	r	*r*	*r*	*r*	*r*
GO Performance Approach	.19**	.20**	-.21**	.07	.13*
GO Performance Avoid	-.11	-.08	.12	.05	-.07
GO Learning Approach	.31**	.44**	-.20**	-.04	.05
GO Learning Avoid	-.27**	-.36**	.21**	.03	.06
GO Task Approach	.21**	.17*	-.19**	.16*	.19*
GO Task Avoid	-.27**	-.24**	.11	-.15*	-.16*
PI Endogenous	.46**	.60**	-.20**	.16*	.07
PI Exogenous	-.41**	-.43**	.28**	-.07	-.04
Positive Affect	.54**	.62**	-.34**	.22*	.14*
Negative Affect	-.13*	-.24**	.48**	.23*	.05
Incremental Belief	.07	.14*	-.10	.01	.01
Entity Belief	-.10	-.15*	.09	.04	-.03
Creative Competency	.32**	.29**	-.07	.08	.01

RESULTS | PROFILES

“Human beings are not lists of independent variables; they are coordinated wholes”

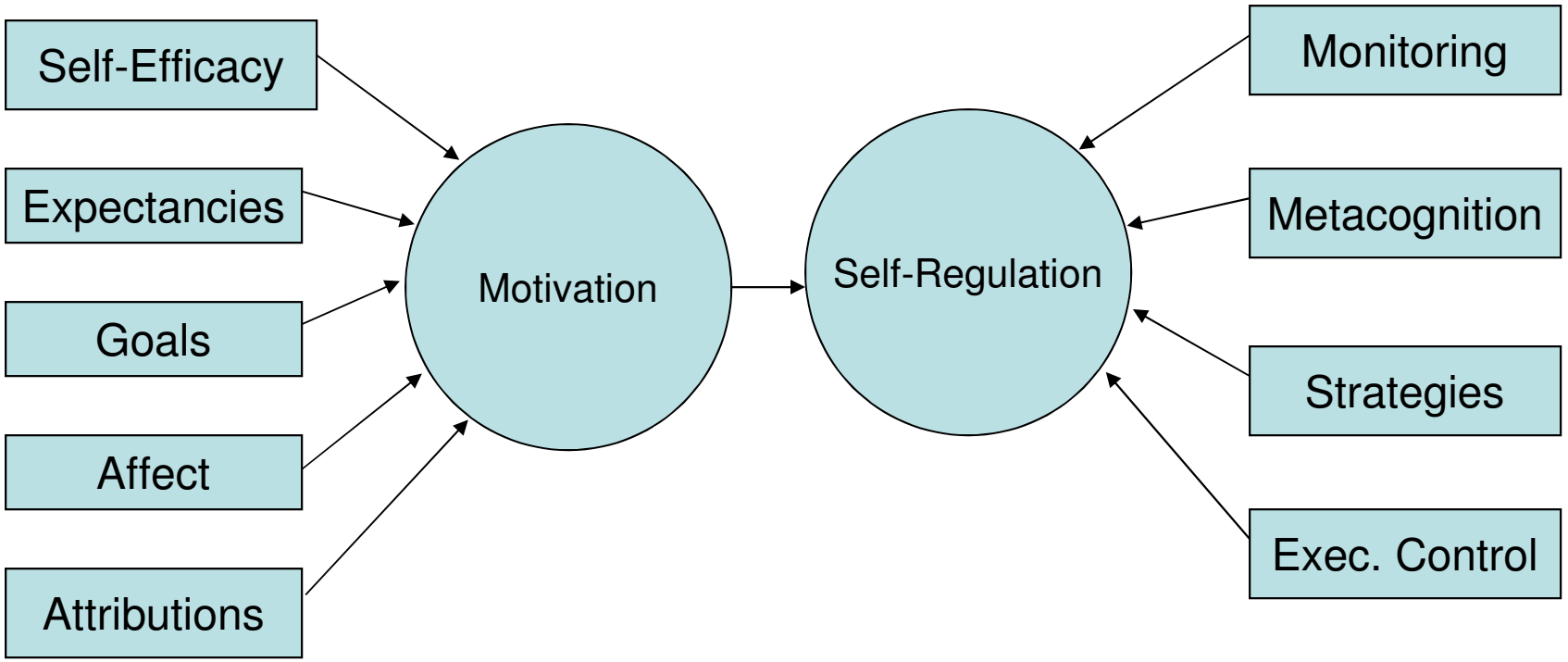
Snow (1992)

RESULTS | PROFILES

At any given place and time, some combination of all possible motivators is producing an overall motivation in a person that is influencing tendencies toward some combination of cognitive, metacognitive, behavioral, and self-regulatory actions.

These combinations can be represented as a profile.

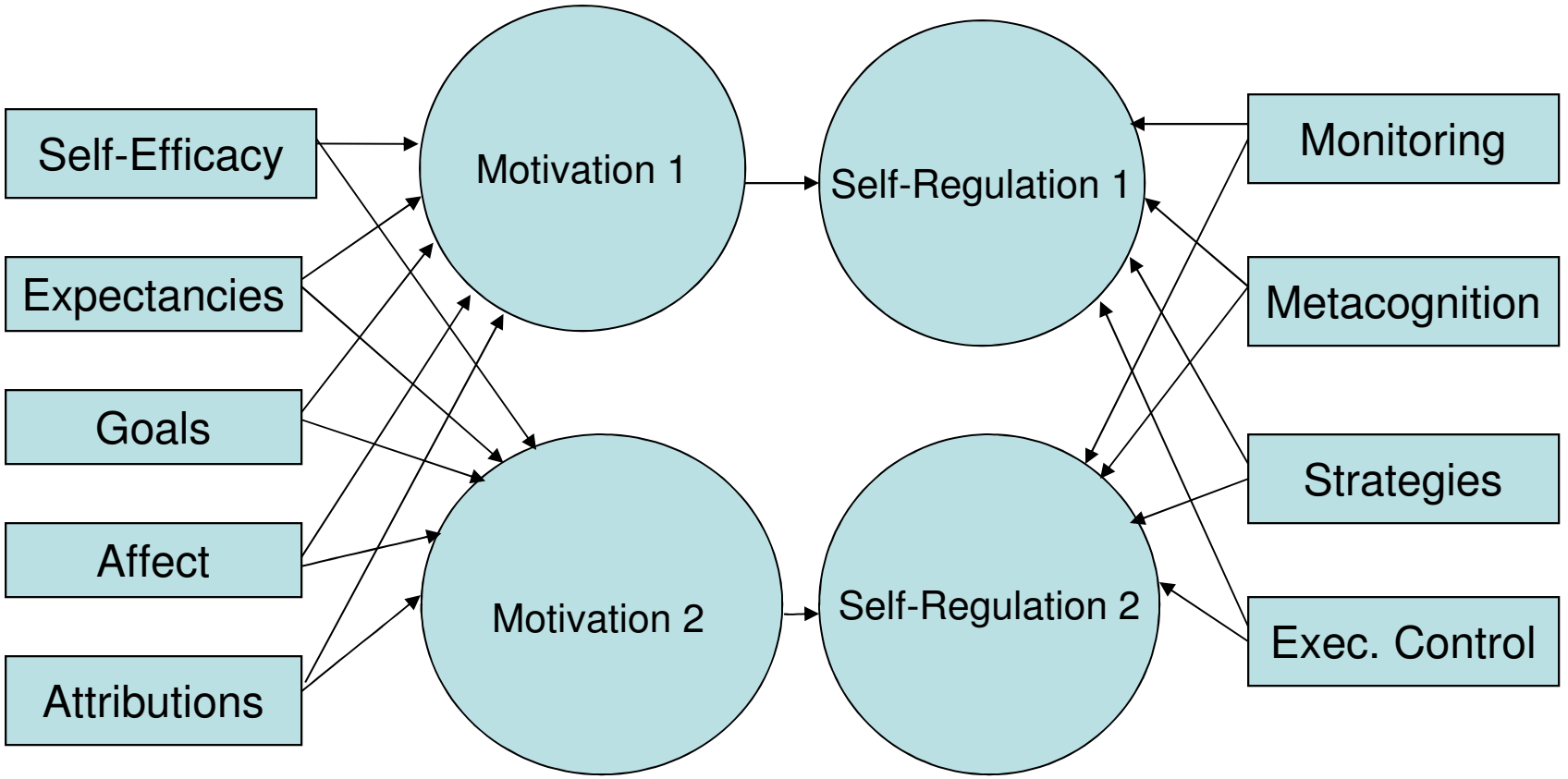
RESULTS | PROFILES



RESULTS | PROFILES

- There may be more than one “coordinated whole”
- Relationships are NOT necessarily one-to-one.
- The contributors to motivation can be dynamically constructed in multiple ways
- Different constructions may be motivating different patterns of self-regulation.

RESULTS | PROFILES



RESULTS | PROFILES

	Strategic	Knowledge Building	Surface Learning	Apathetic	Learned Helpless
SPOCK Self-Regulation	3.84	3.02	3.38	2.32	3.31
SPOCK Knowledge Building	3.70	2.89	2.72	1.87	3.20
SPOCK Lack of Regulation	2.62	2.63	3.25	3.20	3.06
SPOCK High-Level Question Asking	3.50	2.30	2.57	1.67	3.20
SPOCK Low-Level Question Asking	3.44	2.28	2.89	1.85	3.23
Study Time	3.80	2.60	4.68	2.43	3.04
Study Effort	3.33	2.87	3.67	2.63	2.81
Learning-Approach Goal Orientation	4.57	4.15	3.48	3.45	3.20
Learning-Avoidance Goal Orientation	2.03	2.33	3.78	3.55	2.84
Task-Approach Goal Orientation	4.69	4.54	4.66	4.26	3.21
Task-Avoidance Goal Orientation	2.05	2.53	2.86	3.28	2.83
Performance-Approach Goal Orientation	3.33	3.14	2.98	2.39	2.76
Performance-Avoidance Goal Orientation	2.72	2.98	2.91	2.74	2.90
Endogenous Instrumentality	4.42	3.82	2.54	2.50	3.22
Exogenous Instrumentality	1.71	2.03	3.60	3.37	3.01
Future Time Perspective Career	4.23	4.14	4.19	4.01	3.82
Positive Affect	3.82	3.04	2.56	2.21	2.83

RESULTS | PROFILES

	Strategic	Knowledge Building	Surface Learning	Apathetic	Learned Helpless
SPOCK Self-Regulation	3.80	2.56	3.08	2.37	3.44
SPOCK Knowledge Building	3.72	3.20	3.03	2.13	3.04
SPOCK Lack of Regulation	2.37	2.15	2.90	3.28	3.28
SPOCK High-Level Question Asking	3.59	2.06	2.85	2.06	2.97
SPOCK Low-Level Question Asking	3.50	1.97	2.93	2.25	3.07
Study Time	3.93	1.89	3.17	2.30	3.44
Study Effort	3.83	2.10	3.20	2.55	3.35
Learning-Approach Goal Orientation	4.66	4.41	3.55	3.23	4.16
Learning-Avoidance Goal Orientation	1.83	1.92	2.81	3.68	3.31
Task-Approach Goal Orientation	3.09	2.86	2.65	2.91	3.74
Task-Avoidance Goal Orientation	2.48	2.80	2.46	3.13	3.70
Performance-Approach Goal Orientation	4.44	4.26	3.56	3.86	4.53
Performance-Avoidance Goal Orientation	1.80	2.51	2.57	3.29	2.99
Endogenous Instrumentality	4.36	4.32	3.33	2.29	3.54
Exogenous Instrumentality	3.92	3.90	3.25	3.16	3.75
Future Time Perspective Career	4.49	4.13	3.99	3.94	4.34
Positive Affect	3.77	3.13	2.73	2.03	3.04
Negative Affect	1.68	1.49	2.13	2.76	2.51

RESULTS | PROFILES

	Strategic	Knowledge Building	Surface Learning	Apathetic	Learned Helpless
SPOCK Self-Regulation	High	Low	Moderate	Low	High
SPOCK Knowledge Building	High	High	Moderate	Low	Moderate
SPOCK Lack of Regulation	Low	Low	Moderate	High	High
SPOCK High-Level Question Asking	High	Low	Moderate	Low	Moderate
SPOCK Low-Level Question Asking	High	Low	Moderate	Low	Moderate
Study Time	High	Low	Moderate	Low	High
Study Effort	High	Low	Moderate	Low	Moderate
Learning-Approach Goal Orientation	High	High	Low	Low	Moderate
Learning-Avoidance Goal Orientation	Low	Low	Moderate	High	High
Task-Approach Goal Orientation	Moderate	Moderate	Low	Moderate	High
Task-Avoidance Goal Orientation	Low	Low	Low	Moderate	High
Performance-Approach Goal Orientation	High	High	Low	Moderate	High
Performance-Avoidance Goal Orientation	Low	Moderate	Moderate	High	High
Endogenous Instrumentality	High	High	Moderate	Low	Moderate
Exogenous Instrumentality	High	High	Low	Low	High
Future Time Perspective Career	High	Moderate	Moderate	Moderate	High
Positive Affect	High	Moderate	Low	Low	Moderate
Negative Affect	Low	Low	Moderate	High	High

RESULTS | PROFILES

Study 1

Computational Thinking Knowledge Test Scores by Profile Cluster

	Profile Cluster									
	Strategic		Knowledge Building		Apathetic		Surface Learning		Learned Helpless	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Total	9.23_a	2.83	9.50_a	2.68	5.00_b	2.86	5.35_b	2.80	7.07_c	3.33

Note: Means with different subscripts are different at $p < .05$.

Study 2

	Profile Cluster									
	Strategic		Knowledge Building		Apathetic		Surface Learning		Learned Helpless	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Total	6.82	2.47	8.24	2.82	5.02	2.60	5.38	3.29	5.79	2.69

RESULTS | PROFILES

Study 3

	Profile Cluster									
	Strategic		Knowledge Building		Apathetic		Surface Learning		Learned Helpless	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Grade	3.40_{a}	.97	3.12	.94	2.80_{b}	1.18	2.90	.96	3.10	.96
Test	8.46_{ab}	3.14	8.01_{c}	2.99	7.09_{a}	2.94	6.06_{bc}	2.84	5.82_{bc}	2.86

Note: Means with same subscripts differ at $p < .05$.

RESULTS | PROFILES

Cross Tabulation of Profile Cluster by Characteristics of Course and Major

Variables	Profile Cluster									
	Strategic		Knowledge Building		Apathetic		Surface Learning		Learned Helpless	
	n	%	n	%	n	%	n	%	n	%
Course										
CSCE 155 [CSCE Major]	11	20%	28	51%	2	4%	8	15%	6	11%
CSCE 150E [Engineering]	10	11%	11	12%	10	11%	39	41%	24	26%
CSCE 150A [Mixed]	17	32%	14	26%	2	4%	15	28%	6	11%
RAIKE183H [Bus. CSCE]	14	47%	7	23%	0	0%	1	3%	8	27%
Computer Science Major Minor										
Considering	12	30%	13	33%	0	0%	7	18%	8	20%
Not Considering	16	13%	18	15%	11	9%	51	41%	28	23%
Already Major Minor	23	34%	29	43%	2	3%	5	8%	8	12%

RESULTS | PROFILES

Average Student Behavior Measures Across Engagement Profiles
Note: Medians are provided in parenthesis due to non-normality and the skew of the measures caused by outliers

		Engagement Profile				
Measure	**Action**	**Strategic**	**Knowledge Builder**	**Surface**	**Apathetic**	**Learned Helpless**
Connection	**View**	11.852 (11)	11.078 (10)	11.647 (13)	10.744 (11)	9.294 (8.5)
	Edit	3.295 (4)	3.125 (3)	3.725 (4)	3.128 (3)	2.441 (2)
	Comment	2.852 (3)	2.797 (3)	3.059 (3)	2.641 (2)	1.824 (1)
Repetition	**View**	6.475 (5.8)	7.146 (7.798)	7.506 (6.729)	6.084 (5.273)	5.256 (4.059)
	Edit	2.545 (2)	3.122 (2.633)	2.765 (2.4)	2.44 (2.333)	2.118 (1.75)
	Comment	2.46 (2)	3.077 (2.5)	2.645 (2.5)	2.326 (2)	1.709 (1)

Strategic **learners performed high levels of connection and repetition.**

Knowledge builders **performed moderate levels of connection, but high levels of repetition.**

Surface **learners perform opposite knowledge builders: they performed the highest levels of connection, but lower (comparatively) levels of repetition (especially for the more active actions: editing and commenting). Thus, surface learners appear to behave by performing more passive and less intensive actions than the students from other engagement profiles.**

Apathetic **learners performed low levels of connection and repetition, as expected.**

Learned helpless **learners performed the lowest levels of connection and repetition, indicating that in spite of their motivation, their struggles with learning caused them to give up, as predicted..**

FOOD FOR THOUGHT | PROFILES

- Student motivation in CS and other STEM classes is complex.
- Specific motivators may not always motivate strategic self-regulation and engagement in the same ways.
- The same motivator may lead to both productive and dysfunctional strategic self-regulation and behavior.
- We can understand student motivation and strategic self-regulation as “profiles” which portray different patterns or complexes of motivated self-regulated engagement.

FOOD FOR THOUGHT | PROFILES

- Students in different profiles learn and achieve differently.
- The distribution of profiles differs across course
- The distribution of profiles differs for students who are majoring or not majoring in the course subject.
- Profiles are associated with different real time behavior.

REFERENCES

Eck, A., Soh, L.-K., & Shell, D. F. (in press). Investigating differences in wiki-based collaborative activities between student engagement profiles in CS1. *Proceedings of the 47th ACM Technical Symposium on Computer Science Education (SIGCSE'2016)*. New York: The Association for Computing Machinery.

Flanigan, A. E., Peteranetz, M. S., Shell, D. F., & Soh, L.-K. (2015). Exploring changes in computer science students' implicit theories of intelligence across the semester. *Proceedings of the 11th ACM International Computing Education Research Conference (ICER'15)* (pp. 161-168). New York: ACM.

Nelson, K. G., Shell, D. F., Husman, J., Fishman, E., & Soh, L.-K. (2015). Motivational and self-regulated learning profiles of students taking a foundational engineering course. *Journal of Engineering Education, 104*(1), 74-100.

Hazley, M. P., Shell, D. F., Soh, L.-K., Miller, L. D., Chiriacescu, V., & Ingraham, E. (2014). Changes in student goal orientation across the semester in undergraduate computer science courses. *Proceedings of the 44th Annual Frontiers in Education (FIE) Conference,* (pp. 2278-2285). Piscataway, NJ: IEEE.

Shell, D. F., Hazley, M. P., Soh, L.-K., Ingraham, E., & Ramsay, S. (2013). Associations of students' creativity, motivation, and self-regulation with learning and achievement in college computer science courses. *Proceedings of the 43rd Annual Frontiers in Education (FIE) Conference* (pp. 1637-1643). Piscataway, NJ: IEEE.

Shell, D. F., & Husman, J. (2008). Control, motivation, affect, and strategic self-regulation in the college classroom: A multidimensional phenomenon. *Journal of Educational Psychology, 100,* 443-459.

Shell, D. F., & Soh, L.K. (2013). Profiles of motivated self-regulation in college computer science courses: Differences in major versus required non-major courses. *Journal of Science Education and Technology. 22*, 899-913. DOI 10.1007/s10956-013-9437-9.

Shell, D. F., Soh, L.-K., Flanigan, A. E., & Peteranetz, M. S. (in press). Students' initial course motivation and their achievement and retention in college CS1 courses. *Proceedings of the 47th ACM Technical Symposium on Computer Science Education (SIGCSE'2016)*. New York: The Association for Computing Machinery.

CONTACT AND ACKNOWLEDGEMENT

IUSE/IC2Think project website: http://cse.unl.edu/agents/ic2think

Email: lksoh@cse.unl.edu, dshell2@unl.edu

This material is based upon work supported by the National Science Foundation under Grants No. 0829647, No. 1122956, and No. 1431874. Additional support was provided by a UNL Phase II Pathways to Interdisciplinary Research Centers grant.