Computing Students‘ Understanding of Dispositions: A Qualitative Study

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Agenda

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- Methodology
- Data Collection and Analysis
- Results
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Introduction

Motivation for this Research:

- Dispositions are cultivated behaviors desirable in the workplace
- Dispositions, skills and knowledge form the three components of competency (IT2017, CC2020)
- They refer to the human aspect of learning, and reflect a person's individual behavior in a professional context and professional development
- Cultivating dispositions should be part of every educational program, including computing, but many questions remain unanswered w.r.t. to teaching and assessing dispositions
- The **goals** of this study are to:
  - » *Increase the understanding of dispositions and related behaviors, and*
  - » *Investigate observable behavior patterns students associate with dispositions*

Why Dispositions?

- Knowledge: *know-what*
- Skills: *know-how*
- Dispositions: *know-why*, *know-yourself*
  - Includes intent and willingness to apply knowledge and skills in a given context (Freeman 2007, Perkins et al. 1993, Schussler 2006)
- An integrative model of competency is characterized by the synergetic interdependence of all three competency components within the context of a task (Raj et al. 2021)
- Few studies have been conducted in computing, our prior study elicited students‘ understanding of adaptable, collaborative, persistent, responsible, and self-directed (Kiesler et al. 2023)

Table 1: CC2020 Dispositions [9, Table 4.4, p. 51]

Disposition	Elaboration
Adaptable	Flexible; agile, adjust in response to change
Collaborative	Team player, willing to work with others
Inventive	Exploratory, look beyond simple solutions
Meticulous	Attentive to detail; thoroughness, accurate
Passionate	Conviction, strong commitment, compelling
Proactive	With initiative, self-starter, independent
Professional	Professionalism, discretion, ethics, astute
Purpose-driven	Goal-driven, achieve goals, business acumen
Responsible	Use judgment, discretion, act appropriately
Responsive	Respectful; react quickly and positively
Self-directed	Self-motivated, determination, independent

For the experiments, we used persistent instead of purpose-driven

Methodology

Desiderata

- Teaching and assessing dispositions is a relatively new area of research in computing education
- Students' consciousness of dispositions and how they manifest in terms of behaviors have not yet been subject to research

Research Question

1. *How do students understand being meticulous and professional in terms of the behaviors they think they exhibit in completing coursework?*
2. *To what extent do we identify new categories of behaviors students associate with the dispositions adaptable, persistent, and self-directed when completing coursework?*
3. *What reasons do students give for not applying the dispositions adaptable, persistent, self-directed, meticulous, and professional while completing coursework?*

Qualitative study in computing courses at four undergraduate institutions

Explore students' understanding of dispositions by identifying specific behaviors associated with them

Data Collection and Analysis

Data Collection

- Ramapo College of New Jersey (A)
- St. John's University (B)
- College of Charleston (C)
- University of New Hampshire (D)

- 1-3 computing courses/sections per institution
- 3-5 assignments per course were selected
- After each assignment: short survey with an open, reflective questions on each of the five dispositions (*adaptable, persistent, self-directed, meticulous, professional*) and how students applied them in selected assignments (or why not)

Table 2: Academic programs and student composition

Inst.	Type	Academic Setting	Computing Programs	Computing Majors (N)	Minorities %	Women %
A	Public	Liberal Arts	CS, DS, IT	212	31	17
B	Private	Comprehensive	CS, IT, Cyber	417	65	19
C	Public	Liberal Arts	CS, DS, IS	522	23	34
D	Public	Professional Studies	CS, IT, DS	80	12	11

Table 3: Courses used for data collection

Inst.	Course Name	Course Details
A	Computer Science I Programming Languages	Intro (C++) Upper-level
B	Database Management	Upper-level, 2 sections
C	Computer Science I	Intro (Python), 3 sections
D	Foundations of Programming Intro to Web Development	Intro (Python) Intro, 2 sections

Data Collection and Analysis

Data Analysis: Inductive-Deductive

- Students' responses to open questions were qualitatively analyzed (Mayring 2015)
- One response usually served as one coding unit (i.e., each response carried one meaning)
- Inductive categories were built, representing the behaviors students associate with dispositions
- For each category, a definition and anchor examples were developed

Table 2: Deductive categories for *adaptable*, *persistent*, *self-directed* based on the literature [16]

Adaptable	Persistent	Self-directed
Acting despite the unpredictable	Achieving success or long-term goal	Critical self-assessment
Changing problem-solving strategies	Aiming at high quality	Planning ahead
Overcoming difficulties with concepts or new tools	Incresing working hours	Self-review against guidelines and goals
Recognizing the need for changes	Investing constant effort despite frustration	Successful problem solving (learning)
	Participating regularly over project or course	Utilizing external resources

- Iterative process started with 10% of the material, and first categories (for meticulous and professional)
- Every run covered more and more material, and categories were refined or added
- A member check assured a common understanding of the used category
- Categories from prior work (Kiesler et al. 2023) were reused for *adaptable*, *persistent*, *and self-directed*

Results RQ 1: Meticulous

Category	Definition	Anchor Example(s)
Paying close attention to detail	Comprising the details to which students direct their attention, e.g., formatting, comments, correct syntax, visualizations, spelling alignment, brackets, linting errors, readability, checking dependencies Conducting repetitive checks of a solution	"I went through the entire program looking at every single line of code to make sure everything was written properly" "We rechecked multiple times that all relationship types in the graph were correct."
Producing the correct solution	Stresses the actions required to achieve a correct solution to the task and its requirements.	"I made sure I followed every direction in the rubric and did not cut any corners. I used everything I was instructed to use in the program and made sure it functioned properly"
Improving solution (even if not required)	Highlighting intrinsically motivated work, although not requested by the task description, e.g., to make the solution more legible for other programmers, or to improve its quality (e.g., runtime, accuracy, reducing lines of code, etc.)	"I was always looking for ways to improve my program to make it easier to read and understand by any future programmers" "I remember using some code that wasn't necessarily required for the assignment."
Testing code thoroughly	Testing code to ensure it functions in different cases by using test scripts, test data, and addressing the occurring exceptions and errors.	"I checked each query result multiple times to make sure that I was completely satisfied with how specific the results were. We also made sure that there was enough data to make sure every query looked good too." "[...] I made sure there were neither errors nor warnings when I ran the test script."
Accepting feedback	Recognition of feedback from collaborators or educators with the goal of implementing it and improving the solution.	"We always tried to take the feedback and accurately modify our work so that it would meet the requirements of the project"
Applying time management strategies for a timely submission	Planning to conduct the work ahead of time to not run out of time before completing the assignment.	"I will always get an assignment/work done ahead of time because I hate the burden of it on my shoulders throughout the week."

Results RQ 1: Professional

Category	Definition	Anchor Example(s)
Aim at high quality	Having the target audience in mind, striving for a high-quality. Includes legible, understandable, and clean code with, e.g., expressive variable names, interesting, easy-to-follow, concise presentations and reports.	"I did my best to set up the reports [...] to mostly be self-explanatory." "I tried to condense and simplify my program as much as possible." "I included understandable variable names for myself and others." "Before presentations I make sure I practice many times and am prepared to present without flashcards." "To the last pixel everything lines up perfectly and if not I intended it [...]."
	Practice presentations.	
	Paying close attention to detail, e.g., layouts, or alignment of elements, validating and testing code.	
Meeting the requirements	Meeting the standards and what was expected, and finishing the assignment in all aspects with a focus on correctness and completeness.	"I tried checking off everything from the rubric." "I tried to follow all of the goals of the milestone and make sure I was fitting the requirements."
Collaborating with team members	Sharing and discussing ideas with team members, problems and challenges to work towards a solution, including helping each other when encountering problems, planning steps together, and being open to others' ideas.	"My partner and I [...] made sure our ideas matched." "Schedule virtual meetings to go over the assignment and talk about what we may be confused on, and helped each other out." "We always tried to divide the work into smaller pieces." "I also reviewed my partner's work as he did with mine."
	Cooperating with others by splitting up tasks, or reviewing each other's work.	
Applying time management for timely submission	Allocating sufficient time ahead of deadlines to meet them.	"I made sure to allocate a lot of time to getting this done" "Made sure to get it up on time even though I was not fully satisfied with the results."
	Prioritizing a timely submission over perfect results.	
Producing documentation	Using comments to explain the code and every step of it.	"Writing comments explaining the code I have just written." "The comments that describe the computational steps of my solution are very throughout."
Self-knowledge and respective action	Reflecting on one's strengths and weaknesses, and what is expected, before taking appropriate action to solve a problem or the task.	"I tried to practice and finish this program bit by bit each night until I had created a finished product that I could be proud of." "I was able to find ways to assist me during this project."
Respecting team members	When working in teams or with peers, accepting their needs and positions to facilitate a respectful, and convenient work environment for all persons.	"Me and my teammate respect each others time and space and are able to work with each other when it is convenient for both." "All ways respect my partner opinion."
Asking for help	Appropriately asking for help, only when needed.	"Asking for help in a respectful way." "I did as much of the problems as I possibly could on my ow and asked my classmates for assistance on the things that I was not quite grasping."
Accepting feedback	Being open to feedback, listening to it, and taking it into account for the improvement of the assignment.	"We followed the feedback provided to improve our graph." "All ways listen to any advice."

Results RQ 2: Adaptable, Persistent, Self-directed

Reuse of Existing Categories

- Categories from prior work (Kiesler et al. 2023) were confirmed for adaptable, persistent, and self-directed
- For persistent, “seeking help” was defined as a new category of behaviors, for example:
  - “Use all available tools – textbook, notes, google search - to find answers”
  - “Using available tools and resources including asking the Professor questions.”

Adaptable	Persistent	Self-directed
Acting despite the unpredictable	Achieving success or long-term goal	Critical self-assessment
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Results RQ 3: Dispositions not applied

Category	Definition	Anchor Example(s)
Do not have the disposition	Student claims to not possess the disposition	"I don't feel like I am a meticulous person and that applies to this assignment." "I am not able to be professional due to my immaturity."
Lack motivation to apply it	The student is not willing to apply the disposition; motivation or desire is specifically mentioned	"I usually like working reward based and motivated, so being meticulous becomes difficult"
Lack of time management strategies/skills	Running out of time due to poor time management or excessive outside commitments	"I felt like my schedule restricted me from being meticulous, I aimed for making sure features were functional rather than perfect."
Believe the disposition was not necessary	To the student, the disposition seems unnecessary for success on the assignment	"I was never meticulous because I didn't really need to be."
Could not figure out (how to apply the disposition)	Difficulty in understanding the assignment, the tools, or necessary concepts prevents application of the disposition	"I tried to go through every detail to the best of my ability but I was not able to get through some logic errors which caused errors within my project." "I was definitely not professional with this since I was struggling to even make the code work."
Did not apply the disposition	No reason was given for not applying the disposition	"I'm not putting effort into the assignment which is unprofessional." "[...] I intended to revise my code to make it more efficient and did not."
Unwilling to risk applying the disposition	The student believes the disposition is important but is afraid that applying it would cause additional difficulties in completing the assignment correctly	"im not very maticulous, i notice when i get the function or program to work i don't like messing with it in case i end up breaking it."
Belief that disposition is partially applied	The student applies the disposition but not to their full satisfaction.	"I wasn't necessarily professional, I was 50/50."

Discussion

Reflections on the Results:

- **RQ 1**:
  - For *meticulous* and *professional*, categories from other dispositions could be reused, e.g., “Applying time management strategies for a timely submission”.
  - Especially *professional* seemed to overlap with several behaviors associated with other dispositions, e.g., “Aim at high quality”, “Meeting the requirements”, “Collaborating with team members”, “Producing documentation”, “Asking for help”, …
- **RQ 2**:
  - Students seemed to have a similar perception of the surveyed dispositions, for various reasons, e.g., reaching saturation, reliability of coding scheme, or same socio-cultural background of sample
- **RQ 3**:
  - Some students were not aware of dispositions, others have time constraints due to work hours, sickness, and other courses, lack time management strategies, etc. confirming that dispositions are related to the whole person.

Conclusion

This is one of the first studies to explore *how computing students understand five of the CC2020 dispositions in a classroom setting and which behaviors they associate with them*.

The study comprised multiple institutions in the U.S., and courses at different curriculum levels

Students' responses to open-ended questions were a useful source for identifying (observable) student behaviors

Results will help further define dispositions in terms of observable behaviors by aligning them with experts' perspectives:

- A coding scheme of behaviors students associate with new dispositions,
- valuable confirmation of categories from prior work;
- identification of reasons why students do not apply dispositions

An improved understanding can guide educators to design learning experiences that can lead to both fostering and assessing dispositions among computing students

Future work: Engaging educators to foster dispositions

Thank you for your attention.

Do you have questions, thoughts, ideas?

https://dispositions-project.org