

Computing Students' Understanding of Dispositions: A Qualitative Study

Natalie Kiesler, DIPF | Leibniz Institute, kiesler@dipf.de

Bonnie K. MacKellar, St. John's University, mackellb@stjohns.edu

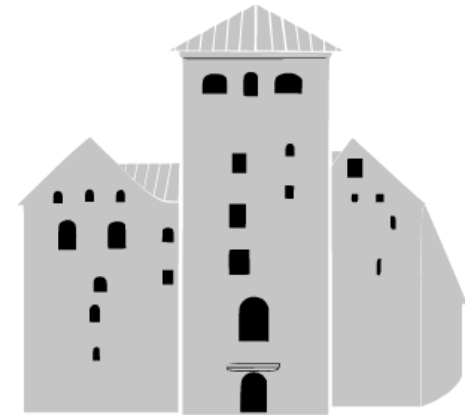
Amruth N. Kumar, Ramapo College of New Jersey, amruth@Ramapo.edu

Renée McCauley, College of Charleston, mccauleyr@cofc.edu

Rajendra K. Raj, Rochester Institute of Technology, rkr@cs.rit.edu

Mihaela Sabin, University of New Hampshire, mihaela.sabin@unh.edu

John Impagliazzo, Hofstra University, john.impagliazzo@hofstra.edu



- Introduction
- Why Dispositions?
- Methodology
- Data Collection and Analysis
- Results
- Discussion
- Conclusion

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
- 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 **goal** of this study is to:
 - » *Increase our understanding of dispositions and related behavior, and*
 - » *Investigate observable behavior patterns students associate with 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)
- Research on dispositions in other fields: teacher education, medicine, nursing, physical education
- Few studies have been conducted in computing

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 |

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

- *How do students at U.S. undergraduate institutions understand dispositions in terms of the behaviors they think they exhibit in 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

- Ramapo College of New Jersey (A)
 - St. John's University (B)
 - College of Charleston (C)
 - University of New Hampshire (D)
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- 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, collaborative, persistent, responsible, self-directed*) and how students applied them in selected assignments

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 Analysis

- 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
- This iterative process started with 10% of the material, and first categories
- Every run covered more and more material, and categories were refined or added
- Two coders participated, intercoder reliability was tested for 184 out of 1238 coding units (14,9%), resulting in a Cohen's κ value of 0.735, which is good
- A member check assured a common understanding of the used category

Table 5: Number of coding units for each disposition across all four institutions

| Adaptable | Collaborative | Persistent | Responsible | Self-directed | Total |
|-----------|---------------|------------|-------------|---------------|-------|
| 234 | 256 | 242 | 258 | 248 | 1238 |

Table 6: Overview of all categories of behaviors associated with each disposition

| Adaptable | Collaborative | Persistent | Responsible | Self-directed |
|--|---|--|---|--|
| Recognizing the need for changes | General communication and exchange | Increasing working hours | Completing submissions | Critical self-assessment |
| Changing problem-solving strategies | Problem-related communication | Investing constant effort despite frustration | Applying time management strategies for a timely submission | Planning ahead |
| Acting despite the unpredictable | Sharing the workload to solve a problem/task together | Aiming at high quality | Checking the quality before submission | Self-review against goals and guidelines |
| Overcoming difficulties with concepts or new tools | Asking for help | Achieving success or long-term goal | | Utilizing external resources |
| | Cooperating with other students | Participating regularly over the project or course | | Successful problem-solving (learning) |
| | Sharing resources | | | |
| | Assisting others | | | |

Table 7: Coding scheme with categories, definitions, and anchor examples for *self-directed* disposition

| Category | Definition | Anchor Example |
|--|---|--|
| Critical self-assessment | General and realistic awareness of one's own capabilities and deficits/lack of expertise Recognizing the need for, e.g., additional resources, help from other persons, or more focus | "I had to learn more about how dynamic memory is allocated and when it can be destroyed" "I worked on it almost everyday" "I worked on it a few hours most nights" |
| Planning ahead | Actions are planned before they are executed, which is due to comprehensible reasons Developing a strategy to solve the problem and direct oneself (e.g., prioritize some actions higher than others) | "I immediately started planning my program structure" "I mostly directed myself to solve the problems at hand using X or Y" "Taking initiative to prioritize the project over sleep" |
| Utilizing external resources | Self-determined selection of additional material, content/persons to support learning and successful problem solving (taking action) Thereby independently learn from previous errors The material usually differs from what the facilitator of the class had provided Resources or research is explicitly mentioned (e.g., documentations, google, videos, texts, sample programs etc.) | "I learned about object-oriented programming in more detail from online sources" "I used many tools I haven't before & researched them myself" "I had to read documentation for a number of things" "I used google a lot when I got errors" |
| Successful problem solving (learning) | Being able to solve problems or tasks successfully without assistance from other persons A solution has been achieved or a learning process has been accomplished independently | "I didn't need help from the professor nor have I discussed with students anything" "For the most part, I had to learn the LISP language all on my own" "I had to figure out how things work with that technology" "I taught myself a lot of things." |
| Self-review against guidelines and goals | Critical consideration & review of one's own actions and results against the provided expectations, guidelines or goals | "I was making sure to the best of my ability the rules of the game were implemented properly" |

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| | Assisting others | | | |

Reflections on the Results:

- Persistent: Students related “*investing time and effort despite frustration*” to this disposition
- Responsible: three categories were straightforward across all four institutions (“completing submissions”, “applying time management for a timely submission”, and “checking quality before a submission”)
- Self-directed: fewer relevant responses in introductory courses (CoC: 53 out of 115 responses), more in upper-level courses (Ramapo College: 36 out of 38 responses reflected relevant behaviors)
- Many categories reflect on the close relation between dispositions and learning (*learning new things* belonging to *persistent*, *successful problem solving (learning)* in *self-directed*, and *overcoming difficulties with concepts or new tools for adaptable*)
- Category “response not pertinent” needs refining (e.g., response was irrelevant, did not match the disposition, or student did not apply disposition in the assignment)
- Reduce the number of questions and surveys related to assignments (survey fatigue)

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- This is the first study 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: A coding scheme of behaviors students associate with dispositions, which will help further defining dispositions in terms of observable behaviors by aligning them with experts' perspectives.
 - This improved understanding can guide educators to design learning experience that can lead to both fostering and assessing dispositions among computing students
 - Future work: A follow-up multi-institutional study eliciting more observable student behaviors for the remaining CC2020 dispositions; engaging educators to foster dispositions

Thank you for your attention.

Do you have questions, thoughts or ideas?

