Contextualized Instruction in Data Science and its Effect on Transfer of Learning

Tomohiro Nagashima

Carnegie Mellon University, Pittsburgh PA 15213, USA
tnagashi@cs.cmu.edu

Abstract. It is believed that designing "in-context" instruction for students so that they can find a relationship between the instruction and their lives/backgrounds is an effective instructional strategy. Educators have adopted this approach called contextualized instruction to make their instruction more meaningful for students. Despite its popularity, however, little is known about the evidence for the effectiveness of contextualized instruction on student learning. Particularly, although contextualization is thought to be deeply involved in the process of transfer of learning, the impact of contextualization on transfer has not been thoroughly explored. Through conducting an experiment in the domain of data science and follow-up interviews, the proposed study attempts to provide scientific evidence on whether and how contextualized instruction helps student learning with a particular focus on its effect on transfer of concepts and skills in data science.

Keywords: Contextualized Instruction, Contextualization, Transfer, Data Science

1 Introduction

1.1 Contextualized Instruction

Integrating specific examples or stories related to students' own lives and backgrounds into instruction is believed to enhance student learning through making explicit connections between the content of instruction and real-world contexts [7]. Educators intentionally or unintentionally adopt this contextualization approach to their teaching as it makes sense to think that instruction contextualized into students' familiar fields/situations would better support student learning. For example, when teaching new vocabulary in a language class, it is considered better to teach them using example sentences rather than simply providing a list of new words and translations without no contextual information on how the words should be used in real-world contexts [13]. The contextualization approach and its implications have become increasingly important with the prevalence of learning technologies which can personalize instruction to students' personal preferences and situations [14].

Contextualization in teaching and learning has been adopted in various ways at different levels of education (K-12, higher education, and adult education) across many

subject areas (mathematics, basic skills education, language learning, and physics) under different definitions and terms [5, 7, 9, 12, 13, 14]. One particularly important difference among these studies and practices is the difference in what they refer to as "context". For example, in the field of language learning, most studies compare an "in-context" condition with a "no-context" condition (e.g. vocabulary in sentences versus vocabulary as a list of words and translations) [5, 9]. Research on contextualization has also examined whether teaching in a context relevant to students' interests would be better than simply providing a real-world context. For instance, in mathematics education, students' out-of-school personal interests, such as sports and movies, were incorporated into the instruction in an online learning environment and it was shown more effective than the approach where no personal interests were incorporated [14]. At community colleges, researchers examine the effect of contextualization at an academic domain level, finding that contextualizing teaching into students' academic background (e.g. contextualizing reading skill instruction into biology for students in a biology major) is more effective than the "de-contextualized" approach where the students' academic background was not considered [7].

Among different definitions and terms for the contextualization approach in these studies, we decided to use the term "contextualized instruction" in this study as its definition in [7] makes an explicit distinction from another popular term, "integrated instruction", and it shares similar motivations and focuses of the strategy. According to [7], contextualized instruction refers to an instructional strategy that integrates specific contexts into the teaching of academic skills, such as reading, writing, and math skills, whereas integrated instruction incorporates academic skills instruction into the teaching of the content. In other words, the focus of instruction is on the teaching of academic skills in contextualized instruction while the focus is on the teaching of the content in integrated instruction [7].

1.2 Problem in the field

One topic that is still yet to be examined in the discussion of contextualization is how contextualizing instruction can contribute to transfer of learning [12]. Defined as "the ability to extend what has been learned in one context to a new context", transfer is considered as one of the most important goals of education [2]. As contextualized instruction involves the strategic use of contexts to help students learn, which is one of the keys for successful transfer [2], several advocates argue that transfer can be meaningfully achieved through the contextualization approach if designed carefully [3, 4, 7, 14]. There is evidence supporting this argument, demonstrating that high school students taught algebra using personalized content according to students' out-of-school interests in an online learning environment successfully transferred the knowledge to more complex problem-solving activities better than students in the de-contextualization group [14]. However, to the best of the author's knowledge, no prior studies have rigorously tested the transfer effect of what we mean by "contextualized instruction" [7]. Given the potential benefit of contextualized instruction on transfer of learning, it is worthwhile to investigate its effect. Note that in our study, transfer of learning refers specifically to the transfer of concepts and skills from one context where those are

learned, to another, or a more abstract context. Also, as it is suggested that transfer can be achieved in a certain situation but not in general [2], it is important to explore when and how contextualized instruction can contribute to transfer, which would then provide implications on the specific designs of contextualized instruction.

1.3 Data Science as the Target Domain

For the proposed study, we chose data science as our target domain. The identification of the target domain was based on our realization that current undergraduate data science education does not necessarily provide a learning experience in the meaningful context for students. Although real-world data and problems may be integrated into its curricula in many university programs [11], data science education does not usually address students' interests and academic backgrounds. In particular, despite the fact that the high demand in the field requires university graduates in a variety of fields to acquire basic data science skill, regardless of their academic backgrounds [6], typical undergraduate data science instruction assumes that students have sufficient background knowledge in data science-related fields, including mathematics, statistics, and/or computer science [1]. This could potentially prevent students with little knowledge in such fields from learning data science effectively as those students would have a hard time connecting the concepts taught with what they know in their familiar contexts and fields. In fact, qualitative research repeatedly suggests that the lack of connections between students and data can negatively impact how students make sense of data and their engagement with data [8, 10]. This implies that it is meaningful to test the approach of contextualized instruction in the domain of data science.

1.4 Research Questions

To improve data science instruction through contextualization, the proposed study investigates whether and how contextualized instruction in an online environment can enhance the understanding and transfer of data science concepts and skills among students having backgrounds in non-data science fields. We are particularly interested in understanding whether contextualizing instruction into a relevant context to students is better than a generic approach where students' familiar contexts are not considered. We will create online data science activities using examples and datasets from the field of chemistry for students coming from the academic background in chemistry. The proposed study, which is part of the dissertation study, examines the following research questions:

- *Will non-data science students taught using contextualized data science activities in their academic background perform better on transfer assessments than those taught using de-contextualized data science activities?*
- *How will contextualized (and de-contextualized) activities contribute to student's understanding of data science concepts and skills?*

2 Method

2.1 Participants

Over 100 subjects will be recruited from several introductory data science and chemistry courses at Carnegie Mellon University in the United States. The target population is undergraduate students majoring in chemistry, which will be identified using data provided by the university. The age range will be from 18 to 23.

2.2 Materials

Instructional Activities. Data science instructional activities will be created on Open Learning Initiative (OLI: www.oli.cmu.edu), a widely-used online learning platform developed at Carnegie Mellon University. Two types of activities will be designed for an intervention. One of them will be contextualized into the field of chemistry (contextualized activities) and the other is "de-contextualized" activities, where the activities are not contextualized into a specific domain or example while they still ask same concepts and skills as contextualized activities. For contextualized activities, relatively easy examples in chemistry will be chosen from an introductory chemistry textbook so that the context will be easily understood by every participant in the study.

Assessments. We will develop two types of data science problem-solving assessment problems where one of them is contextualized into chemistry and the other is de-contextualized. These problems will involve the same concepts and skills as the instructional activities used in the intervention but use different examples and values. We will use these assessment problems to examine the effect of contextualized instruction on the transfer of learning.

2.3 Study Design and Procedure

We will conduct an experiment where we vary the type of instructional activities (contextualized or de-contextualized: independent variable). Our dependent variable is the two types of assessment problems (contextualized or de-contextualized). Half of the students in the contextualized instruction group will receive contextualized assessment problems and the other half will receive de-contextualized assessment problems. Similarly, half of the students in the de-contextualized instruction group will work on contextualized assessment problems and the other half will be given de-contextualized assessment problems. Participants will be randomly assigned to either of these four groups: 1) contextualized instructional activities and contextualized assessment problems, 2) contextualized instructional activities and de-contextualized assessment problems, 3) de-contextualized instructional activities and contextualized assessment problems, 4) de-contextualized instructional activities and de-contextualized assessment problems.

They will be first asked to solve either contextualized or de-contextualized instructional data science activities depending on the group they belong to. Two weeks later,

they will be told to work on the data science assessment problems. All the procedure will be conducted on OLI and students will individually access the materials.

We hypothesize that the contextualized instructional activities will have a positive effect on the performance on the assessment problems, therefore expecting that groups 1 and 2 will perform better than groups 3 and 4 on the assessment problems. We also hypothesize that group 1 will perform better than group 2 and group 4 will perform better than group 3 because students in the groups 1 and 4 will not have to transfer the learned concepts and skills into a more abstract context or a more concrete context, respectively. For those groups involving transfer of knowledge from one context to another, we expect to see that group 2 will perform better than group 3 on the assessment problems because of the expected benefit of deep connection making for the contextualized instruction group.

Following the experiment, 3 to 5 students in each of the conditions will be randomly selected and invited for follow-up interviews where the students will be asked how they approached the activities, whether there was any difficulty in solving problems, and how contextualized (or de-contextualized) activities helped them understand data science concepts and skills.

3 Progress so far

We have identified past literature on the topic of contextualized instruction and designed the study as discussed above, based on and improving upon the study designs employed in the prior work. We are currently developing the instructional activities and the assessment activities. We will conduct the experiment and the interviews in 2019.

4 Contributions

The proposed study will make contributions to the TEL field on the following two aspects:

- *The study will provide evidence on the effectiveness of contextualized instruction in data science, particularly on whether it contributes to transfer of learning*

As discussed above, the effect of contextualization on transfer is not yet established. We expect that providing scientific evidence on the transfer effect would be helpful in the research community and would produce meaningful research questions. For example, future research can test the transfer effect of contextualized instruction in other academic domains. Future studies can also examine the approach of providing multiple opportunities for initial learning in contextualized instruction and its effect on transfer [4].

- *The study will suggest how contextualization should be designed, especially with the use of learning technologies.*

In terms of the practical use of the approach of contextualization, the complexity of the topic and the lack of consistent evidence on its effectiveness we currently see prevent educators from designing effective contextualized learning activities. We aim to suggest several design implications on contextualized instruction to enhance transfer of knowledge among students not only in data science but also in other related domains, based on the findings from the experiment and the interviews. Particularly, we will provide implications on the use of learning technologies because adaptive learning technologies can promote the practices of contextualized instruction in effective and efficient ways [14]. Such implications on how to design contextualized instruction can foster meaningful communications between researchers and practitioners and can eventually improve classroom practices.

References

1. Anderson, P.: Bowring, J.: McCauley, R.: Pothering, G.: Starr, C.: An undergraduate degree in data science: curriculum and a decade of implementation experience. In: Proceedings of the 45th ACM Technical Symposium on Computer Science Education, pp. 145-150. ACM, New York (2014).
2. Bransford, J.: Brown, A.: Cooking, R.: How people learn: brain, mind, experience, and school. National Academy of Science, Washington (2000).
3. Cognition and Technology Group at Vanderbilt. Anchored instruction and its relationship to situated cognition. Educational Researcher, 19(6), 2-10 (1990).
4. Gick, M.: Holyoak, K.: Schema induction and analogical transfer. Cognitive Psychology, 15(1), 1-38 (1983).
5. Gillam, S.: Gillam, R.: Reece, K.: Language outcomes of contextualized and decontextualized language intervention: results of an early efficacy study. Language, Speech, and Hearing Services in Schools, 43, 276-291 (2012).
6. Patil, D.: Building data science teams: The skills, tools, and perspectives behind great data science groups. O'Reilly Media, Sebastopol (2011).
7. Perin, D.: Facilitating student learning through contextualization. Community College Research Center Working Paper (2011).
8. Philip, T.: Olivares-Pasillas, M.: Rocha, J.: Becoming racially literate about dat and data-literate about race. Cognition and Instruction, 34(4), 361-388 (2016).
9. Prince, P.: Second language vocabulary learning: the role of context versus translations as function of proficiency. The Modern Language Journal 80(4), 478-493 (1996).
10. Rubel, L.: Lim, V.: Hall-Wieckert, M.: Sullivan, M: Teaching mathematics for spatial justice: an investigation of the lottery. Cognition and Instruction, 34(1), 1-26 (2016).
11. Song, I.: Zhu, Y.: Big data and data science: what should we teach? Expert Systems, 33(4), 364-373 (2016).
12. Taasoobshirazi, G.: Carr, M.: A review and critique of context-based physics instruction and assessment. Educational Research Review 3, 155-167 (2008).
13. Uswatunnisa. Contextualized and decontextualized vocabulary learning to enhance vocabulary understanding. PhD Dissertation, Diponegoro University.
14. Walkington, C.: Using adaptive learning technologies to personalize instruction to student interests: The impact of relevant contexts on performance and learning outcomes. Journal of Educational Psychology 105(4), 932-945 (2013).