AC 2007-2883: AN ANALYSIS OF BEHAVIOR PATTERNS IN GENERATION Y ENGINEERING STUDENTS AND THEIR IMPLICATIONS IN THE TEACHING-LEARNING PROCESS

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Abstract

The issue of multitasking behavior and the impact of technology in the generation of students populating the classrooms of today's engineering programs have created contradicting views among those who advocate for new patterns in the teaching-learning process and those who support traditional methods. This paper presents an analysis of the learning styles and behavioral patterns of a segment of computer engineering students and professors where the pervasiveness of information and communications technologies have begun to reshape the student behavior, creating questions on its implications in the teaching-learning process of engineering disciplines.

Introduction

"Generation Y" is a term frequently used to designate the cohort of people born from the late 1980s through the end of the 1990s or even the beginning of the new millennium[1,2]. In some cases, this group of people is also referred to as the *Millennials* or the *Net generation*[3,4]. According to this designation, most of the students populating the classrooms of today's engineering programs belong to this generation. This particular group of individuals possesses a set of characteristics that make them unique and different from all previous generations, including that of their professors, counselors, and supervisors.

Generation Y students came to live in a world were Information and Communication Technologies (ICT) are ubiquitous, the bombardment of fast paced information, simultaneously coming from multiple sources is commonplace, and the integration of both has given birth to several new forms of non-traditional communication. Examples include chat rooms, internet messaging, blogs, e-mail, pod casts, and news feeds, just to mention a few. Such an environment stimulates a behavior in which individuals split their attention into slices to handle the multiple tasks they are presented at once. This behavior, denominated *multitasking*[7,8], becomes prevalent in many of these individuals, and often arises in the academic environment.

Professors, counselors, and supervisors, on the other hand, come from different times. They grew-up in a slower paced world where most of today's ICTs were considered gadgets of science fiction or luxury items. Also, for this group, traditional means of communication were the de-facto standard and single-tasking teaching/learning processes were dominant.

These particularities tend to create a generational gap between these groups, leading to mismatches between expectations and practices in the academic environment. Such disparities have been observed in other groups with similar conditions, such as in school age students and their teachers while using personal computers[6]. Moreover, the undeniable role played by ICTs in today's life brings up contradicting opinions regarding the rules to be applied to their use in a college-level academic setting and the impact they have in the student performance.

In this paper we present the findings of a preliminary assessment exercise aimed at shedding some light onto the controversy and to gain insight into the issue of multitasking as an individual trait or a behavior encouraged by technology. Our objective is to characterize the learning styles and multitasking behavior of a segment of the engineering academic population where these new patterns and behaviors appear to be more accentuated. The assessment uses as target population the freshman and senior classes in a Computer Engineering Program, as well as a sample of the professors teaching the last group. This sample population allows for characterizing learning styles, teaching strategies, and expectations from each side to create the basis for postulating new hypotheses that could bring new light into the controversy.

The rest of this document has been organized as follows. The next section examines the work of several scholars with different views on the issue. Next we describe the academic environment where our study was conducted and the target population . Next, we describe the study questionnaire and their administration methods. The last two sections present the results and analysis of our study, to end with a summary and the future steps in this research.

Related Work

Multitasking has been defined as the ability of humans to simultaneously handle the demands of multiple tasks through task switching[7,8]. When referring to emerging types of learners and particularly, to the Generation Y or Millennials, Mestre[9] describes them as inherently multitasking since they have been immersed in the digital environment from a very young age. They tend to be visual learners, and benefit from lots of tactile experiences. They prefer a lot of interactivity, the use of mobile tools, and social networking. However, the effect of multitasking and technology in learning processes is a highly controversial issue. Below, we examine the views of several researchers and scholars who have studied the problem from different perspectives.

Adams[10] discusses how the multitasking behavior of the generation of students who grew up under the influence of the Sesame Street program and having wireless network access in their classrooms was influenced by such programs and technologies. He acknowledges the advantages that computers have brought into education by providing tools for collaboration, simulation, classroom management, information collection, and dissemination. But he also points that these advantages have brought an unfair competition to most of the classroom activities, because students using laptops with wireless access to the Internet have now the world at their fingertips. He argues that uncontrolled access to Internet in the classroom has two factors that may be detrimental to effective learning: distracting activities (e.g. games, chatting, or just browsing websites); and the perception that there are right answers to many questions, that facts themselves are valuable, and that thinking is irrelevant, *i.e.*, the so-called *Sesame Street syndrome*. Adams states that students are not performing tasks simultaneously but making decisions about where to turn their attention next, which consumes energy and encourages the pursuit of instantly pleasurable inputs, while the lecture gets fewer time slices. When referring to learning styles, Adams closely agrees with Metre when he argues that Sesame Street students are sensing, visual, inductive, active and global learners, while most university instruction assumes deductive, intuitive and passive learning styles.

Studies on multitasking and student learning suggest common traits on individuals who learn through performing simultaneous tasks. These students are described as visual, global, and active learners, which are learning styles proposed by Felder and Silverman[11]. Spink[12] conducted a case study to empirically investigate how an information seeker multitasks and the patterns of multitasking information behavior and information task switching. This was achieved through a mix of data collected through observations, journal entries, and interviews. The model suggests that multitasking information behaviors and information task switching is affected by: (1) the nature and complexity of content in relation to the information seeker's domain knowledge, (2) the amount and depth of information processing required for different information tasks, (3) the information seeker's level of interest, including their attention and focus, in the information task, (4) the level of planning and priorities by the information seeker in relation to their information tasks, (5) the pros and cons or the effects on effectiveness, efficiency and productivity of information tasks switching, and (6) serendipity by the information seeker that is prompted by visual information cues and the tension with the planning and priority goals. According to the researcher findings, multitasking information behaviors may allow users to cope with the complex everyday world in which they live.

Friedman and Deek[13] have approached the theme trying to answer the questions of whether innovation and new technology developments impact or not education and how education could take advantage of new technologies. In their study, they survey previous works to conclude that education can definitely benefit from new technologies. Their study, at some points, brings up controversial arguments such as pointing that teachers are not anymore the gatekeepers of knowledge, implying a paradigm shift from traditional educational environments. Moreover, based on the argument that the Internet has broken the barriers of time and space they support the notion that students need not be in the classroom for the teaching-learning process at the same time as the teacher.

Based on a study by anthropologist Elinor Ochs, Director of UCLA Center on Everyday Lives of Families, Wallis[12] discusses in Time Magazine the problem of modern American families and the effect of pervasive home gadgets that promote multitasking. He argues that even though family members may be sharing the same physical space, psychologically each one is in his or her own little universe, making difficult for parents to penetrate the child's universe, and impairing communication. This statement also agrees with Bugeja's "digital displacement" concept, as cited by Tucker[15]. Although Wallis recognizes that human beings are inherently capable of performing tasks simultaneously, *e.g.*, driving while listening to the radio, he takes a stand of seeing multitasking as a two-folded problem that weakens family communication and divides attention among many small slices. To support this position he uses arguments from Jordan Grafman, Chief of Cognitive Neuroscience at the National Institute of Neurological Disorders and Strike in Bethesda, whose research indicates that the quality of one's output and depth of thought deteriorates as one attends to ever more tasks. According to Grafman's research, the brain does not actually handle multitasking, except for highly automated tasks, but toggles among tasks rather than simultaneously processing them. More recent studies at Toronto's Rotman Research Institute suggest that, as we get older, it becomes more difficult to turn down background thoughts when switching attention to a new task, leading to an increase in decision errors and taking longer to complete tasks.

Hembrooke and Gay[16] studied the effects of multitasking on students in an upper level communications course at Cornell University. The study was part of a research investigating the effects of wireless computing in collaborative learning environments. Two groups of students heard the same lecture; group A was allowed to open their laptops while group B was not.

Immediately after the lecture a test of traditional measures of memory for lecture content was performed. Investigators found that students in group A suffered decrements in information retention compared to those in group B. Statistical significant differences were found in the recall and total scores. However, differences only approach statistical significance in the recognition part of the tests. Browsing behavior was also analyzed and students in group A were classified depending on whether the URLs visited were or not related to the lecture contents. An inverse relation arose between the recall scores and browsing lecture related sites. Conversely, as students spent more time visiting unrelated pages they obtained higher recall scores. Using Lang's Limited Process Capacity model, the authors were able to analyze their results beyond the basic predictions of divided attention theories and postulate that sustained distraction seems to be the cause of decreased performance. Another interesting finding of this work is that while multitaskers did poorer in traditional tests of memory, their performance in the class overall did not reveal the same disruption.

Recognizing that ICT usage by the new generations of students is a no turning back point, Skiba and Barton[5] suggest that educators are faced with the challenge of adapting their teaching styles to accommodate a new generation of learners who have expectations, styles, and needs different from past students.

Some studies on multitasking and student learning suggest the existence of common traits among students who learn through performing simultaneous tasks. They describe these students as visual, global, and active learners, according to learning styles preferences proposed by Felder and Silverman[11]. Researchers like Cuthell[6] believe that it is the nature of multitasking that creates thinkers with these attributes, while others believe that students have their own styles which compete with and in many cases oppose traditional instruction. Cuthell goes a step further by proposing that the integration of computers with the individual's understanding and thought processes will create new ways of thinking.

Lauria[17], considered the father of neuropsychology, has formulated that sociohistorical shifts not only introduce new content into the mental world of human beings, but also create new forms of activity and new structures of cognitive functioning. The bibliography by Varela[18] in the field of neurophenomenology has long recognized that technology would necessarily impact human beings by transforming social practices and breaching the philosophical circle that defines the interactions between teaching and learning practices. These lines of thinking open the possibility of being in the verge of a new breed of individuals who, influenced by the pervasiveness of technology can actually multitask and excel.

Presented with these challenges there are many questions that arise considering the possible relationships between technology use in the classroom and the multitasking behavior of our current student generations. A hypothesis brought in this discussion is whether or not multitasking is becoming a learning style by itself or if multitasking has become an inherent trait of this and coming student generations.

Methodology

Academic Environment

The University of Puerto Rico (UPR) system is the state owned higher education institution in the island of Puerto Rico. The system is composed of eleven campuses, from which the Mayagüez Campus (UPRM), the second largest in the system, is the only one granting engineering degrees. The Computer Engineering (CE) program at the UPRM is offered by the Electrical and Computer Engineering Department, which serves about 1,500 students, i.e. roughly ten percent of the campus population. From these, about one third are undergraduate CE students. Students entering into the Computer Engineering program are required to have a minimum admission index (IGS[19]) of 348/400, the second highest entry index in the UPR system. This requirement brings to the program top high schools students from all over the island.

Engineering programs at the UPRM are five years long. In the CE program, the first two years are primarily devoted to mathematics, science, humanities, Spanish, English, and economy courses. In years three and four, the basis of CE is built with core courses in the areas of software, hardware, and communications. In the fifth year, students take mostly technical elective courses. The program is structured to fulfill both breadth and depth of knowledge and concludes in the fifth year with a major design experience through a capstone course identified as the "Design Project in Computer Engineering".

The particular academic setting where participating students were chosen included four courses: one at the freshman level and the remaining three at the senior level (fifth-year students). The freshman course selected for the study was "UNIV-0004: Skills for College Life Success". This is a non-credit course offered by the Department of Counseling to all incoming campus freshmen to help them have a smooth transition into university life and to provide them with the necessary skills to cope with this change. Topics discussed in the course include time management, decision making, study skills, assertiveness, and stress management. For our assessment exercise, only the answers provided by those students enrolled in the CE program were considered.

The fifth-year students who participated in the study, were enrolled in the courses Digital Microelectronics (INEL-4207), Microprocessor Interfacing (ICOM-5217), and/or Capstone Design in CE (ICOM-5047). From these courses, ICOM-5217 is a technical elective, while the other two are program requirements. All three courses provide a balanced blend of choices in terms of career concentrations in the three program areas. The materials discussed in the three courses have varied perspectives. INEL-4207 is a traditionally conducted course teaching transistor-level circuit design and VLSI, with exams and periodic homework. ICOM-5217 teaches the basis of embedded systems design and firmware development through a student proposed, semester-long project[20]. In the capstone course students are expected to conduct a semester-long project which involves advanced hardware and software concepts. Students in this course typically seek meaningful projects in which they feel a contribution is made to society. The work is conducted in groups, so teamwork and conflict management skills are put in place. The project is expected to be a large and complex project in a real world setting.

In all the surveyed courses, and particularly the last two, students are allowed to use their laptops or tablet PCs in the classroom, as well as calculators, PDAs, and/or pocket PCs, although none is required to do so. Outside the classroom, chatting, searching and surfing the web, using email, consulting technical forums, and using cell phones are among the widespread practices to work in the projects and coordinating teamwork.

Target Population

Our assessment exercise used as target population freshman and senior students in the CE Program, as well as professors teaching senior level courses. The participants included 74 students (21 females and 53 males) distributed as 51 freshman and 23 seniors. From these, 35 students came from public schools and 39 from private high schools. The professor sample included five individuals (one female, four males) in total. The group included the professors teaching the three senior courses from where students were surveyed plus two other faculty members teaching other senior courses where student responses were not collected. The mean of years teaching of the sample of professors was 13.8 years. In total seventy-nine people participated in the study (n=79). Our department has 15 faculty members who teach CE courses at the senior level. Ten of these professors were approached to participate in this exercise and only five of them completed the questionnaire.

Survey Structure

The students participating in this exercise voluntarily completed a questionnaire on the use of technology in the classroom, as a course assessment activity. The participants were asked demographical questions, questions on the use of technology inside and outside of the classroom, ratings of self-perceived multitasking behavior, and learning styles. The Felder and Soloman Index of Learning Styles[11] (ILS) was used. Originally, the student sample had 76 participants, but two sets of answers were eliminated due to incomplete responses and missing data.

The professor participation was also based on a voluntary basis, driven mainly by the curiosity of how their perceptions regarding technology and multitasking behavior would result compared to those of their students and to provide meaningful data to this exercise. The professors completed the ILS and an individual self-report questionnaire with 70 items related to the use of technological devices in the classroom.

The instruments used in the study can be described as follows:

1. *Index of Learning Styles*[11] by Felder and Soloman, consisting of 44 items.

2. *Use of Technology in Classroom- Student's version*: a self-report questionnaire, developed exclusively for the assessment exercise. This instrument was directed at evaluating the use of technology devices by students inside and outside the classroom, and the simultaneous use of them while in the classroom. The questionnaire consists of 54 items distributed as: 11 demographic questions, 15 on the usage of technology in the classroom, five on the general use of technology, 12 exploring reasons why students use technology in the classroom, 8 exploring the technology used by professors in the classroom, its effectiveness, and the perceived professors' attitude towards technology, and three on self perceived multitasking behavior.

3. *Use of Technology in Classroom – Professors' version*: a self-reporting questionnaire developed for the assessment exercise. The instrument evaluates the use of ICT devices by professors inside and outside the classroom and their simultaneous use while in the classroom. This version consisted of 70 items; five demographical questions, 63 related to the knowledge and use of ICT devices inside and outside the classroom, and two questions of self-perceived multitasking behavior. In the 63 technology items, five were open questions about the length of time professors spent with ICTs and three directed to identifying all the ICTs used inside and outside the classroom. Fifteen questions asked how often multiple ICTs were simultaneously used in the classroom, with answers on a Likert scale ranging from 1= *very often* to 5= *never*. Eight items inquired about the use of specific ICTs in the classroom with answers on a Likert scale ranging from 1=*completely agree* to 5=*completely disagree*. Also, the level of proficiency in using devices or tools (e.g. Weblogs, RSS, and word Processing tools among others) was measured with a Likert scale from 1= *I do not know* to 5= *very proficient*. Thirteen questions assessed how often professors applied technology in the teaching process, and nine asked how frequently students requested the professors to use ICTs in class. Both sets of questions were answered using a Likert scale ranging from 1=*very often* to 5=*never*.

Research Design and Administration

The investigators conducted a descriptive assessment exercise. The main objective was to identify the apparent multitasking behavior of Computer Engineering students and professors in the teaching and learning process. Descriptive and inferential statistical analyses were used.

Results and Analysis

Student Component

The analysis of the questionnaire on learning styles indicated that our student sample was predominantly visual, sensing, and sequential with a balance between active and reflective learning styles. Table 1 shows the frequency and percentage of students and the totals of professors for each reported learning style. These results partially agree with Adams predictions, except that our results point to students with a more dominant sequential style.

Table 1: Summary of student and professor preferred learning styles.

	Students							Professors
	Balanced		Moderate		Strong		Total	Total
	No.	%	No.	%	No.	%	No.	No.
Active	22	29.7	12	16.2	7	9.5	41	2
Reflective	22	29.7	8	10.8	2	2.7	32	3
Sensing	27	36.5	21	28.4	2	2.7	50	4
Intuitive	17	23.0	5	6.8	1	1.4	23	1
Visual	16	21.6	33	44.6	14	18.9	63	5
Verbal	6	8.1	4	5.4	0	0	10	0
Sequential	21	28.4	22	29.7	4	5.4	47	1
Global	21	28.4	5	6.8	0	0	26	4

The results on the exhibited multitasking behavior showed that 73.5% (n=54) of the sample used more than one ICT device in the classroom. Table 2 shows the number of students that reported using a particular ICT simultaneously with some other device in the classroom. Note that some of the students reported using both, scientific and graphic calculators. Table 3 provides results on the use of computer related technologies in the classroom.

Among seniors, 52% reported surfing the web while in class compared to 29% of freshmen. In both groups 30% reported using Google in the classroom and 24% of freshmen versus 30% of seniors chatted while in the classroom. Table 4 shows the types of ICTs owned by the students:

Table 2: Number of students who use ICTs simultaneously with other devices in the classroom

Electronic devices	Frequency	Percentage
(Students N=74)	No.	%
1. Laptop	29	39.2%
2. Tablet	1	1.4%
3. PDA	1	1.4%
4. MP3 Player	3	4.1%
5. Cell phone	15	20.3%
6. Graphic Calculator	40	54.1%
7. Scientific Calculator	39	52.7%

Table 3: Number of students who use technologies in classroom

Electronic device	Frequency	Percentage
(Students N=74)	No.	%
1. Surf the internet	27	36.5%
2. Chat	19	25.7%
3. Games	6	8.1%
4. E-mail	30	40.5%
5. Google	23	31.1%

Table 4: Number of students who own ICT

Electronic device	Frequency	Percentage
(Students N=74)	No.	%
1. Laptop or tablet	58	78.4%
2. PDA	8	10.8%
3. MP3 Player	3	4.1%
4. Cell phone	15	20.3%
5. Graphic Calculator	40	54.1%
6. Scientific Calculator	39	52.7%

In general, there were no apparent differences between freshmen and seniors in the patterns of use of equipment and functions in the classroom. Therefore, the student sample was considered homogeneous. While 78% of both freshmen and seniors reported having or owning a laptop, only 31% of freshmen and 57% of seniors indicated using them in the classroom. 68% of the students reported that laptops were allowed in the classroom. 82% of students in both groups reported to have cell phones and 16% of the freshmen students reported they use the cell phone in the classroom versus 22% of senior students. This is considered a high usage since only 8% of the sampled students reported that cell phones were allowed in the classroom, while 100% of the surveyed faculty reported cell phones were not allowed in their classrooms. We are interested in further understanding how students interpret the use cell phones in the classroom.

We found that 33% of freshmen and 43% of seniors have MP3 players but 2% and 4% respectively use them in the classroom. Also, 9% of the students reported these devices were allowed in the classroom.

With respect to the use of calculators, 55% of the students indicated they were allowed in the classroom, more than 70% reported having calculators but only 50% reported they used them in the classroom.

Analyzing the trends of and how often students use specific technological devices simultaneously with other devices in the classroom, we found the following:

- Students use more scientific calculators than graphic calculators
- Around 80% of students rarely or never use graphic calculators and cell phones and other devices simultaneously during class.
- Also between 60 and 80% of students rarely or never use MP3 players, PDA, or other devices simultaneously during class.
- Between 45 and 50% of students very often or often use laptop or table computers and other devices simultaneously during class.
- Between 60 and 77% of students rarely Google, send emails, play games, or chat simultaneously while in class.
- When students use the "Laptop", "Tablet" or "PDA" in the classroom 55% rarely or never get connected to the internet or a messenger system.

In respect to the teaching tools used by professors, students agree that a book (76%), the blackboard (64.9%), computers and PDA's (58%), and calculators (78%) are effective complements for the professor in the classroom. Similarly, 57% of the students said that professors allow technological devices during exams.

In the professor sample, all the surveyed professors (n=5) reported they used PowerPoint for class presentations. Among students, 48% agreed that a class completely taught in PowerPoint contributes to learning, while 27% disagreed with that statement.

Students strongly disagreed about the idea of using the calculators (70%), MP3's (80%), or cell phones (79%) to disconnect when the professor or the class is boring, or when they do not understand the class.

There was a high variability in the times students reported spent in activities like internet, messenger, playing games, or talking in the phone or cell phone. On average students said they used a laptop to navigate through the internet for approximately 4.2 (SD 2.6) hours daily. They use a messenger system for 3.7 (SD 3.4) hours daily, talk on the phone and cell phone 1.7 (SD 1.9) and 2.3 (SD 2.2) hours daily, respectively. In general, a student who uses the phone or cell phone, at most, spends 10 hours daily. Likewise, students who use a laptop to navigate the internet or a messenger system spend typically 12 hours a day.

Professors' Component

The results show that three out of the five surveyed professors used more than one technological device in the teaching process while in the classroom. The same number reported using a laptop, one used PDAs and a scientific calculators, and one reported using the cell phone. In relation to the technological functions used simultaneously in class the results show that two surf the internet, and only one used chat, email, and google simultaneously. From those sampled, two reported no simultaneous use of ICTs while in the classroom. All of the five sampled professors reported they were, at some level, multitaskers in the classroom. Two of them considered themselves highly multitasking while the other three said they were moderate multitaskers. They also reported multitasking outside the classroom. Two self rated themselves as high multitaskers, one moderate, and two low multitaskers.

In relation to how often professors used specific ICTs or functions simultaneously in the classroom, our results show that laptops are the most often used devices along with other devices. Four professors reported using the laptop very often simultaneously with other devices like scientific calculator, and PDA. When using the laptop or PDA in the classroom, two professors reported they sometimes navigated the internet; one reported doing it often, while the other two indicated they rarely or never navigate the internet while in the classroom.

The results also indicate that professors used less cell phones, tablets, and MP3 players than students. Three of the five professors surveyed never used the cell phone simultaneously while in class, and four of them never used tablets, graphic calculator or MP3 players in the classroom.

When analyzing the application of technology in the teaching process the results showed that four professors used often or very often the email with students for class purpose, and four often or very often provided students access to online resources. Also, two sometimes or very often corrected project and homework online, and all five used PowerPoint for class presentations. All of the surveyed professors reported applying sometimes or very often technology for promoting group discussions and for providing practice exercises in their courses. In addition, two reported the use technology to administer assessment exercises. In terms of allowing the use of technology by students, two of the surveyed professors allowed students to use a laptop, tablet, PDA and/or graphical calculator in their classrooms, while three allowed the use scientific calculators.

With respect to the learning styles, the last column in Table 1 shows that professors are predominantly visual and sensing, with balance between active and reflective, similar to what the students reported. On the other hand, students were more sequential while professors reported to be more global.

Summary and Future Work

The findings of this assessment exercise provided both expected and unexpected results. In the expected side we confirm our initial assumptions that Y generation students have a multitasking behavior both inside and outside the classroom. Among unexpected results our analysis points to a great similarity between professors' and students' behavior and their perception with respect to multitasking. This finding refutes the idea of a generational gap, except for the learning styles of both groups. In general both groups were balanced between active and reflective, predominantly preferring visual information and reported to be more sensing than intuitive. With respect to global and sequential learning styles, students reported to prefer information presented in sequential from rather than global, contrasting with the preferred learning style of the surveyed professors. We have to recognize that the professors who responded the survey share the same curiosity and behavior with the authors of the study. This might create biasing in the sample. It would be interesting to find if this pattern would prevail when a larger portion of the CE professors is included.

We also found that the academic activities, particularly in seniors, promote multitasking behavior. Students are not only allowed to use ICT devices, but also are encouraged to use multiple technical, information, and communication resources. However, one could argue that actual multitasking may not actually be taking place but a single task, *i.e.*, conducting the project, where students use multiple resources to solve one single complex problem. Even in this case, it could also be argued that the use of multiple resources may take the student out of concentration thus having effects similar to multitasking. But the line of thought in problem solving may not be considered interrupted but halted while looking for a solution for a difficulty.

Questions that remain unanswered include whether the multitasking behavior is actually contributing to a better formation of the students, and whether the professors are taking advantage of this fact to tailor their teaching methods. These are areas of continuing interest and activity in our group.

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