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Are iGen Freshman Different? Notetaking Habits of STEM Students: A Descriptive Study

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Abstract

Notetaking practices (e.g., modality, strategies) as well as confidence with notetaking has been linked to college success. A descriptive study was undertaken to explore the notetaking practice of a sample of freshman STEM students (n=139) over the duration of their first semester in college. The study found that iGen STEM students prefer taking handwritten notes when entering college, and that this preference persists throughout the first semester. Students report using a variety of strategies consistently throughout the semester while taking notes (e.g., abbreviation, summarizing, highlighting) and a desire to improve their time efficiency with notetaking. Students report use of more active learning strategies when interacting with their notes by the end of the first semester. While the amount of time spent engaging with their notes remained constant at 2.5 to 3 hours per week per class, more students created their own test questions, used drawing and labelling, and wrote connections between concepts by the end of the first semester. STEM students from the iGen generation demonstrate a preference for handwritten notes. They appear to adjusted their notetaking strategies over the semester and interacted with their notes in ways that supported learning.

Keywords: Note-Taking, iGen, Freshman

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INTRODUCTION

Student-centered interactive pedagogies in science, technology, engineering, and mathematics (STEM) courses in higher education have been shown to increase learning and have been recommended as best practices (National Research Council, 2012). However, a recent survey of 25 institutions and 2000 STEM courses indicates that lecture remains the dominant pedagogical method with 87% of class time spent with students listening to the instructor and taking notes (Stains et al., 2018). Thus, notetaking continues to be a critical aspect of academic success in higher education for STEM students (McGuire, 2015; Peverly et al., 2013). It is a key component of learning as it assists students with making connections between content, organizing material, and retaining information (Boyle et al., 2015; McGuire, 2015; Peverly et al., 2013). The primary method of notetaking for decades has been handwriting, however this began to change in the late 1990s with the advent of portable computers (Luo et al., 2018; Quade, 1996). Since then, technology options which include laptops, tablets, and smartphones, have allowed students to take notes digitally by, for example, typing notes into word processing software (Stacy & Cain, 2015).

Shortly after students began to type their notes, scholars began to debate whether these digital notes were of the same quality and thus had equivalent ability to foster learning as handwritten notes (Quade, 1996). Extensive research has been published on this topic, and much is now understood about the benefits and drawbacks of digital notetaking (Aguilar-Roca et al., 2012; Bui et al., 2013; Fried, 2008; Hembrooke & Gay, 2003; Luo et al., 2018; Mueller & Oppenheimer, 2014; Quade, 1996; Skolnik & Puzo, 2008; Wurst et al., 2008). Surprisingly, however, little research has been conducted regarding college students' notetaking practices more broadly. Understanding how students take notes is critical to understanding how students learn from lectures, and, ultimately, supporting students in taking full advantage of notetaking as a tool to foster their academic success (Morehead et al., 2019; Witherby & Tauber, 2019). In fact, only two studies (Morehead et al., 2019; Witherby & Tauber, 2019), both published in 2019, have addressed this topic in the last 40 years. Prior to this, one study was published in 1974 by Palmatier and Bennett who noted that a dearth of studies on this topic had been conducted since the 1940s. Much has changed in academia since the 1940s, and even the 1970s, from teaching-learning methodologies to available educational technology. Thus, updating the knowledge base related to notetaking practices of college students is essential given the crucial role that quality notes has on college success (Annis, 1981; Boyle et al., 2015).

Morehead et al. (2019) and Witherby and Tauber (2019) have begun to fill this gap. Morehead et al.'s (2019) sample consisted of students (n=312) enrolled in psychology courses whereas Witherby & Tauber (2019) surveyed students (n=364) of a variety of majors and minors but their results are not broken down by type of majors. Results of both studies revealed that over 90% of students report taking notes in class, and approximately 85% of students report taking handwritten notes (Morehead et al., 2019; Witherby & Tauber, 2019). Students have reported that their notetaking modality depends on the style or discipline of the class (Morehead et al., 2019). STEM students may have different notetaking habits given the nature of the course that they take. For example, science students include diagrams during notetaking, which may influence their notetaking practices (Manalo et al., 2013). Thus, extrapolating from the Morehead et al. (2019) or the Witherby and Tauber (2019) article to STEM students would be ill advised. Further, current generation of students, the iGen generation, are much different from the students of the 1970s. iGen students have been termed "digital natives" since they have grown up with access to high speed internet, smart devices, and ever-advancing technology (Gose, 2017). Their status as digital natives may, in fact, shape their notetaking practices, making them, for example, more inclined to take digital notes than previous generations. To ascertain the degree to which current students are true digital natives, it is important to determine their confidence in their own computer skills.

What aspects of iGen STEM students' notetaking practices shall be investigated? The extensive literature about aspects of notetaking that influence the quality of notes and the success of students was examined. Given that much of the research conducted on college notetaking is related to notetaking modality (e.g., handwritten, typed notes), better understanding iGen STEM students'

natural notetaking modalities in courses, as opposed to notetaking modalities contrived by a study's group assignment (e.g., Aguilar-Roca et al., 2012; Bui et al., 2013; Chen et al., 2017; Kim, 2018; Luo et al., 2018; Luo et al., 2016) is important.

Related to notetaking modality, studies have found that students can type faster than they can handwrite, thus, they have the ability to capture more information, resulting in more verbatim notes (Bui et al., 2013; Mueller & Oppenheimer, 2014). During digital notetaking, about 20% of students took verbatim notes, whereas 36.5% paraphrase information (Witherby & Tauber, 2019). More captured information may yield notes of greater quality in terms of accuracy, completeness, and detail (Bonner & Holliday, 2006). However, it has been hypothesized that students who take verbatim notes do not process information properly (Mueller & Oppenheimer, 2014). Given these findings, questions related to what information students are attempting to capture while taking notes (i.e., strategy), whether digital or handwritten, is important.

The literature tells us that notetaking modality is not the only important aspect of notetaking. Students need to be engaged with their notes for true learning to occur (Ramsay & Sperling, 2011). Paraphrasing, restating, recopying, and creating visual notes are examples of the ways that students can engage with the information present in their notes (Luo et al., 2018; Ramsay & Sperling, 2011). Along the same line, time spent reviewing notes, reason for taking notes, and review strategies are important aspects of notetaking (Luo et al., 2018; Morehead et al., 2019). Regardless of notetaking modality, it is thus critical to learn from students about the strategies that they use to engage with their notes.

A final aspect of notetaking found to be important in the literature is confidence. Carrier (1988) found, three decades ago, that freshman lack self-confidence in notetaking. They also found a negative relationship between confidence and final grades, with students who lacked confidence in notetaking having lower grades (Carrier et al., 1988). Little research has been conducted on this topic since. Witherby and Tauber (2019) found in their study that college students felt confident in their notetaking abilities, however just short of half of the sample stated that they would participate in a workshop about improving their notetaking abilities. This is concordant with the study by Morehead et al. (2019) who found that nearly 60% of students reported that they wished they had better notetaking abilities. Given the relationship between confidence and grades, understanding the degree of confidence of iGen STEM students in their notetaking abilities is crucial.

There are multiple gaps in knowledge related to iGen STEM college students' notetaking practices that must be filled. For this purpose, a descriptive study was undertaken to answer the following research questions:

1. What are the notetaking practices (i.e., modalities, strategies, engagement, and confidence) of freshman STEM students?

2. Do freshman STEM students have similar patterns of notetaking practices at 3 time points within their first semester (at the start, midterm, and final weeks) in college?

METHODS

Since the published literature contains little information on the notetaking practices of the current generation of freshman STEM students, a descriptive study was designed for the intention of gathering information to understand their current notetaking choices and inform future studies. Descriptive studies capture characteristics of groups of people without introduction of an intervention or manipulation of variables, making it an appropriate choice for the type of information being gathered (Portney & Watkins, 2009).

Sample and Recruitment Procedure

Participants were recruited from all sections of two science courses (i.e., biology and chemistry) taken by first semester students at a medium-sized private nonprofit university on the east coast of the United States. The students in all the course sections of these courses were eligible to participate in the study. The informed consent process occurred in class, with instructors' permission, during the first two weeks of the semester. Students who consented to participate in the study completed a first set of questionnaires at that time (Time 1). Students who wished to participate in the study, but who were not at least 18 years old were asked to have their parents sign the informed consent form. Of the 214 potential subjects, 139 students signed the informed consent form. A summary of the demographic information for all participants is provided in the narrative of the result section.

The study sought and obtained approval from the university's institutional review board. Data safety and subjects' anonymity were protected through the use of password protected electronic files on a secure network, codes to identify subjects, and physical copies of the measurement tools and informed consent forms being kept in a locked file cabinet.

Data collection procedure

The second, fifth, and sixth authors collected data at three points during the Fall semester of the participants' freshman year: Time 1 (weeks 1-2), Time 2 (weeks 5-6), and Time 3 (weeks 10-12). The data were collected during chemistry or biology class periods at the convenience of the course instructors. The data collected in class consisted of paper questionnaires which took approximately 20 minutes to complete.

Two questionnaires were the primary source of data for the study: Sociodemographic Questionnaire (SDQ) and the Notetaking Abilities and Strategies of University Students (NASUS). The SDQ, administered at Time 1, was created by the research team to collect background information regarding participants' age, ethnicity, socio-economic background, educational profile including those of parents, standardized test tests taken, any previous diagnosis, hours of study and work, and major of study.

The NASUS was administered at all three time points to collect information about the participants' current notetaking modalities, strategies, and confidence. The NASUS was developed by the research team given that no existing questionnaire of modern multi-modal notetaking modality, strategies and confidence existed. The content validity, test-retest reliability, construct validity, and concurrent validity of the NASUS were established concurrently to this study (Chabot et al., 2021). A multi-step process was used to develop the questionnaire and establish its content validity including literature review, divergent item generations by multiple groups of graduate students, pilot testing, and revisions. Items were clustered into 6 domains related to modality, strategy, and confidence: notetaking modality used, frequency of notetaking modality used, reason for taking notes, desired aspects of notetaking to be improved, time spent reviewing notes, and note organization and review strategies. Response formats varied from question to question and included yes/no, percent of time, and Likert scales ranging from agree to disagree. The test-retest reliability of the questionnaire was established using statistical approaches based on the response scale of questions (i.e., ordinal "% of time", binary selected / not select, and Likert-type scales). Across the 13 ordinal items, the average test-retest reliability, using Spearman's rho, was $\rho = .68$. Binary items showed an average of 83% of participants selecting the same answer across the two administrations. Finally, average scores computed within the three questions that contained Likert-type items (i.e., Q4=confidence, Q5=satisfaction and Q9=computer literacy coefficient alphas = .88, .77, .83) showed good test-retest reliability with average Pearson correlation coefficients: $r = .81$ for Q4; .82 for Q5, and .73 for Q9. Further examination of concurrent validity between specific items showed that the confidence and satisfaction with notetaking scores measured by Q4 and Q5 were significant predictors of notetaking

strategies, especially whether or not participants indicated a need for improvement of their notetaking abilities.

Data Analysis

All analyses were performed using the R Statistical Programming Language (R Core Team, 2018) with additional use of the following R packages: *psych* (Revelle, 2018) and *reshape2* (Wickham, 2007). The primary analytic approach was descriptive. For each of the items on the NASUS, descriptive statistics per time period were computed. Due to the exploratory nature of the study, and the number of items analyzed, inferential methods were not used to examine changes across time periods. It was not our intention to test hypotheses regarding change over time, but rather to record descriptive statistics at three time points. This approach was chosen because categorizing particular changes as significant institutes an arbitrary threshold and may inflate the probability of Type I errors (McShane et al., 2018). As such, we present the normative data culled at each of three time points and qualitatively describe the differences among reported levels of each response at each time point.

RESULTS

Participants' Characteristics

The majority of the 139 participants were full-time college freshmen students enrolled in introductory level science courses who identified as female. Most participants identified as White or Caucasian. Most of the sample reported being enrolled in a health-related major (e.g., pre-med, health sciences) with other reported majors being one of the following: engineering, biochemistry, biology or chemistry. The National Science Foundation defines STEM education as including natural sciences, computer and information sciences, engineering, mathematics as well as the social and behavioral sciences (Gonzalez & Kuenzi, 2012). STEM undergraduate areas of study include biology, biochemistry, chemistry, all biomedical fields, biopsychology, multiple specializations in engineering, technology, and mathematics (Fiegener, 2013). The mean age of participants was 18.43 (SD = 1.00) indicating that their ages were representative of traditional college freshmen and that they are of the iGen generation. One-hundred six participants reported taking the SAT prior to college, with an average self-reported score of 1249.93 (SD = 191.72) which places them in the 86th percentile nationally. Approximately 80% of participants reported that at least one of their parents had some college degree (i.e., associates, bachelors, masters or doctoral degree) with the majority having a bachelor's or master 's degree (~64%). Participants were also asked about any diagnoses that may affect their learning with the most reported diagnoses being anxiety and depression; slightly more than half the participants explicitly reported having no disability. Table 1 provides further details about the characteristics of the study participants.

Table 1 Participant Characteristics

Item	Frequency	Percentage
Gender Identity (n=137)		
Female	102	74
Male	34	25
Non-binary	1	0.7
Undergraduate Status (n=138)		
Freshman	101	73
Sophomore	24	17
Junior	8	6
Senior	5	4
Race (n=137)		
Asian	16	12
Black or African American	7	5
Hispanic or Latino	10	7
Pacific Islander or Native Hawaiian	2	1
White	57	41
Other	1	0.7
Academic Major (n=134)		
Architecture	7	5
Biology	12	9
Biochemistry	3	2
Biopsychology	1	0.7
Environmental Sustainability	1	0.7
Health Science/Athletic Training	2	1
Health Science/Nursing	11	8
Health Science/ Occupational Therapy	12	9
Health Science/ Physician Assistant	30	22
Industrial Design	1	0.7
Interior Design	3	2
Mechanical Engineering	3	2
Premedical Studies	36	27
Premedical Studies Accelerated	2	1
Psychology/Occupational Therapy	4	3
Other, unspecified	6	4
Parent Education Level (n=138)		
Less than high school/GED	8	6
High school diploma/GED	19	14
Associates degree	16	12
Bachelors degree	44	32
Graduate degree	44	32
Doctorate degree	6	4
Not applicable	1	0.7
Reported Diagnoses (n=121) *		
Attention Deficit Disorders (ADHD/ADD)	8	7
Anxiety	26	21
Blind or Vision Impaired	7	6
Chronic Health Condition	1	0.8
Deaf or Hard of Hearing	1	0.8
Depression	13	13
Learning Disability	2	2
Not Applicable	71	59

*Some participants reported multiple diagnoses.

Along with their sociodemographic data, participants provided information about their study habits and how much time they worked for pay during a typical week in the semester. During the first week of the semester (Time 1), just over 62% of participants reported studying for 15-19 hours a week or less. The reported number of hours studying did not appreciably change at Time 2 (62%) nor Time 3 (65%). At Time 1, participants estimated spending an average of 2.54 (SD = 1.07) hours per week reviewing their notes, while the average at Time 2 was 3.02 (SD = 1.23) hours, and the average at Time 3 was 2.61 (SD = 1.08) hours. In terms of work, the majority of participants reported working

less than four hours a week for pay and this increased over the semester (Time 1: 56%, Time 2: 62%, Time 3: 68%). However, some participants reported working up to 24 hours a week per pay period. This increased from Time 1 to Time 3 (Time 1: 3%, Time 2: 6%, Time 3: 7%).

Notetaking Modality

The first question participants answered about notetaking modality consisted of the 14 items shown in Table 2, along with the statement "I use another notetaking technique" to which participants could add other modality. Participants chose one of five options to indicate the percentage of time they used each modality in class: never, 1 to 25% of the time, 26-50% of the time, 51 to 75% of the time, and 76% of the time or more. Over 92% of participants responded "never" when asked if they used another notetaking modality, so that item is not shown in the table.

The table illustrates noteworthy tendencies among participants at all three time points. First, participants still seem to prefer handwriting their notes; at all three time points, about 60% of participants reported using this modality over three-quarters of the time. Second, items 4, 5, 9, and 10 all pertain to the use of technology such as video and audio recording, or specialized notetaking software (e.g., Sonocent, Evernote, and OneNote). A large majority of participants reported never using these modalities at all time points. However, participants did seem to be open to using audio recording devices as the semester progressed. Finally, though a small percentage of participants reported not taking notes, the vast majority of participants indicated that they "never" engaged in no notetaking at all three time points.

Table 2 Participants' Report of the Percentage of Time Spent Engaging in Different Notetaking Modalities

	Time 1 (N = 139)					Time 2 (N = 92)					Time 3 (N = 74)				
Item	Never	1-25%	26-50%	51-75%	76%+	Never	1-25%	26-50%	51-75%	76%+	Never	1-25%	26-50%	51-75%	76%+
1. I handwrite my notes on printed PowerPoint™ Slides*	47**	27	9	7	10	57	20	8	3	13	61	1	11	9	7
2. I handwrite my notes on the handout provided by the instructor	8	30	25	25	12	15	27	28	17	12	26	22	23	24	5
3. I handwrite on my own notebook paper	0	5	12	17	66	1	2	11	14	72	8	3	10	19	60
4. I handwrite on a tablet PC or iPad	59	18	12	6	5	62	11	10	13	4	65	16	3	8	8
5. I audio record the lectures	81	12	4	2	1	65	14	10	8	3	64	8	11	7	11
6. I video record the lectures	91	7	1	1	1	87	7	3	2	0	91	5	0	4	0
7. I type my notes in Microsoft Word™, Google doc or other word processing software	23	20	19	17	21	25	17	13	21	23	34	16	23	12	14
8. I type my notes on the PowerPoint™ slides	64	22	4	7	3	57	20	10	7	7	60	9	12	15	4
9. I type my notes in the Sonocent software	99	1	0	0	0	83	8	5	3	1	77	9	5	4	4
10. I type my notes in the Evernote or OneNote Software	89	5	1	2	2	91	5	1	1	1	91	4	0	5	0
11. I type my notes on my phone	64	27	6	2	1	79	17	2	2	0	69	18	7	3	3
12. I take a picture of the notes written on the board	9	24	28	27	13	9	26	24	34	7	14	28	23	22	14
13. I copy someone else's notes	36	45	14	3	2	58	35	3	3	1	63	25	5	5	1
14. I have a person who take notes for me	96	4	0	1	0	98	1	1	0	0	93	3	1	3	0
15. I do not take notes during class	86	10	2	0	1	88	8	4	0	0	84	7	8	0	1

Note. * Students indicated a single response for each item. ** These values represent the percentage of students who provided this response choice.

Notetaking Strategies

The second question participants answered pertained to the specific strategies they did or did not use *while* taking notes. Participants were given a list of strategies (Table 3) and asked to check all that applied in response to the question "which notetaking strategies do you currently use regularly?" Table 3 lists the percentage of participants who did not check each item ("no") and the percentage that did ("yes").

A large majority of participants at each time point indicated that they regularly used abbreviations in their notes, and that they tended to summarize lecture material as it was presented to them. Despite the large majority of participants using abbreviations, about half reported still trying to write everything the instructor said at each time point. Participants also showed a preference for using either pictures or diagrams, highlighting, or underlining parts of their notes. This did not seem to change appreciably throughout the semester. However, there was an 11-point increase in the percentage of participants using diagrams from Time 1 to Time 2. About half of the participants reported using color coding schemes during notetaking.

Table 3 Percentage of participants indicating that they use each of eight strategies while taking notes.

	Time 1 (N = 139)		Time 2 (N = 92)		Time 3 (N = 74)	
Item	No	Yes	No	Yes	No	Yes
1. I use abbreviations when taking notes*	32.37	67.63	28.26	71.74	28.77	71.23
2. I summarize the lecture as it is being presented	29.50	70.50	30.43	69.57	30.14	69.86
3. I try to write everything the instructor says	51.80	48.20	59.78	40.22	50.00	50.00
4. I compare notes with my classmates after class	76.26	23.74	80.43	19.57	84.93	15.07
5. I include pictures or diagrams in my notes	30.94	69.06	19.57	80.43	24.32	75.68
6. I highlight parts of my notes	28.06	71.94	30.43	69.57	37.84	62.16
7. I underline parts of my notes	19.42	80.58	16.3	83.70	18.92	81.08
8. I color code my notes	57.55	42.45	56.52	43.48	57.53	42.47

Note. * Participants could select (i.e., Yes) as many notetaking techniques as they used.

Engagement with Ones' Notes

Use of Notes

An important aspect of understanding notetaking practices of freshman STEM students is to learn about how they use their notes, an aspect of engagement. Participants were asked to check-all-that-apply from an exhaustive list of strategies that they could use to engage with the notes taken in class. Table 4 lists the type of use along with the percentage of participants who checked each one ("yes"). Not surprisingly, nearly three-quarters of the participants indicated the use of flashcards as a strategy to engage with their notes. Interestingly, the distribution of ways to use their notes at Time 2 shifted to include a wider array of strategies used by a majority of participants. Flashcard use still dominated the strategies (~78% of participants), but there were upticks in the percentages of participants who indicated annotating their notes ("writing connections"), explaining information out loud, and using diagrams or models. A small percentage of participants reported comparing notes with classmates after class (Table 3). Finally, while nearly all participants reported *not* using a tutor to aid their studying at Time 1, 25% of them indicated that they *did* seek tutoring at Time 2, while ~16% reported doing so at Time 3.

Table 4 Percentages of each of eight strategies used to engage with one's notes.

	Time 1 (N = 139)		Time 2 (N = 92)		Time 3 (N = 74)	
Item	No	Yes	No	Yes	No	Yes
1. I create flash cards (e.g., paper, Quizlet)	30.43	69.57	21.74	78.26	31.08	68.92
2. I create test questions to assess my own learning	78.99	21.01	77.17	22.83	58.11	41.89
3. I write all the information that I recall on a blank piece of paper to assess my own learning	71.01	28.99	56.52	43.48	59.46	40.54
4. I write connections in my notes using the textbook, other readings and materials, classroom discussion, problem sets, etc.	57.25	42.75	38.04	61.96	48.65	51.35
5. I explain the information in my notes out loud	42.75	57.25	32.61	67.39	40.54	59.46
6. I create mnemonics, sayings, songs or games	57.97	42.03	46.74	53.26	54.05	45.95
7. I draw and label diagrams, models, etc.	42.03	57.97	22.83	77.17	31.08	68.92
8. I review my notes with a tutor	94.20	5.80	75.00	25.00	83.78	16.22

Primary reason for taking notes

The literature tells us that the reasons for taking notes is important and related to how students will use their notes (i.e., engagement). The next question participants answered pertained to their reasons for taking notes. Participants were given a list of five reasons for taking notes, and asked to check all that applied in response to the question "What are your primary reasons for taking notes?" Table 5 lists the five reasons along with the percentage that did ("yes") and did not ("no") check each item. While each item was indicated as a primary reason for notetaking by robust majorities of participants at each time point, they were nearly unanimous about using notetaking as a memory aid. Specifically, between 93 and 97% of participants indicated that they took notes to help them remember information presented in class. The results were similar in terms of having a resource for studying. Participants also reported taking notes to understand material, though the percentage of participants answering no to that reason was higher than the "remember information" item.

Table 5 Percentages of participants indicating each of five primary reasons for taking notes.

	Time 1 (N = 139)		Time 2 (N = 92)		Time 3 (N = 74)	
Item	No	Yes	No	Yes	No	Yes
1. To help me pay attention in class	28.78	71.22	27.17	72.83	24.32	75.68
2. To help me remember information shared in class	5.76	94.24	3.26	96.74	6.76	93.24
3. To help me understand the information shared in class	10.79	89.21	13.04	86.96	13.51	86.49
4. To have as a resource to complete course assignments	24.46	75.54	18.48	81.52	25.68	74.32
5. To have as a resource to study for quizzes and/or exams	8.63	91.37	5.43	94.57	10.96	89.04

Confidence

Two aspects of confidence were investigated in this study: confidence with notetaking and confidence with using computers.

Confidence in Notetaking Practices

Participants were asked a series of 11 questions related to their confidence with different aspects of their notetaking practices on a 6-point scale (1=Strongly Disagree, to 6=Strongly Agree). A median score for the 11 questions was computed for each participant at each data point. Participants, on average, have fair confidence in their notetaking abilities and this confidence changes by 0.5 point over time with the lowest average at Time 2 [Time 1 Mean = 4.57 (SD = 0.88); Time 2 = Mean 4.06 (SD = 0.93); Time 3 Mean = 4.91 (SD = 1.07)]. This pattern of change in the average median scores remains similar when only participants for whom we had complete data set across all three data points were included [n=56; Time 1 Mean = 4.49 (SD = 1); Time 2 Mean = 4.54 (SD = 0.92); Time 3 Mean = 4.89 (SD = 1.12)] with the exception of the second datapoint which does not show a dip in confidence. The percentage of participants whose median confidence score across all questions was 4 or above (4 being the lowest score on the confidence side of the Likert scale) was also computed. At Time 1,

57.97% of participants met this criteria, at Time 2 59.09%, and at Time 3 68.66%. The first of the 11 questions asked participants to rate their overall confidence in their notetaking abilities (i.e., "I am confident in my note-taking abilities"). To ascertain the relationship between the remaining questions and the overall confidence question, a linear regression analysis was performed. All the questions were moderately correlated (0.556- 0.65) with the first question as expected since they captured different aspect of notetaking confidence. The R^2 value ranged from 0.31-0.42 with questions 2 "I feel I am writing or typing everything I need during class" and 6 "My notes are detailed" each explaining 17.64% of the overall confidence. Question 10, "My notes are useful when I study for quizzes or exams" explained 16% of the variation in overall confidence.

Ways to Improve Own Notes

To learn more about the underlying reasons behind participants' perception of their notetaking abilities (i.e., confidence), they then answered a question that provided a list of ways they might like to improve their notes. They were asked to check all that applied. Table 6 lists each of the improvements with "no" corresponding to the percentage of participants not checking an item in the list, and "yes" corresponding to the percentage of participants who checked that item. Participants seem to find their own notes legible as a majority of them did not indicate that they wanted to improve the legibility of their notes at each time point. There was mixed support for all other improvements except time-efficiency. At the start of the semester, just over 70% of participants desired to make their notes more time efficient, however, the percentage dropped five points at each additional time point.

Table 6 Percentages of students indicating each of eight different "ways to improve" their notetaking.

	Time 1 (N = 139)		Time 2 (N = 92)		Time 3 (N = 74)	
Item	No	Yes	No	Yes	No	Yes
1. Legible	74.82	25.18	81.52	18.48	83.78	16.22
2. Helpful	54.68	45.32	51.09	48.91	68.92	31.08
3. Accurate	63.31	36.69	61.96	38.04	72.97	27.03
4. Complete	50.36	49.64	57.61	42.39	62.16	37.84
5. Concise	44.60	55.40	41.30	58.70	47.30	52.70
6. Clear	58.27	41.73	59.78	40.22	67.57	32.43
7. Organized	48.20	51.80	48.91	51.09	56.76	43.24
8. Time-efficient	29.50	70.50	34.78	65.22	41.89	58.11

Note. Students could check all that applied.

Use of Software and Computer Confidence

A final set of four items was designed to gauge the confidence of participants in relation to the use of software and computer (i.e., 6-point scale from 1 = strongly disagree to 6 = strongly agree). This was given to assess whether or not participants felt confident in their computer skills as this may impact someone's notetaking modality preference. Table 7 gives the results of the competence set of items. Not surprisingly, on average, participants reported being able to download software, and indicated relatively high confidence in their ability to learn to use new software. They also reported relatively high confidence in their general computing skills. In contrast, the interest in learning new learning technologies dropped across the time periods.

Table 7 Participants' Confidence with their Ability to Use Software and Computers

	Time 1 (N = 139)		Time 2 (N = 92)		Time 3 (N = 74)	
Item	M	SD	M	SD	M	SD
1. I am interested in learning to use new technologies.	4.32	1.35	3.57	1.51	3.50	1.45
2. I can download software on my computer.	4.80	1.40	4.6	1.23	4.73	1.47
3. I am confident in my ability to learn how to use new software.	4.49	1.40	4.34	1.44	4.47	1.54
4. I am confident in my ability to learn new computer skills.	4.56	1.43	4.43	1.35	4.59	1.43

DISCUSSION

The present study investigated freshman STEM students' notetaking practices, specifically, modalities and strategies used as well as degree of engagement and confidence with their own notes. The sample represented a typical college-age sample of iGen freshmen who were high achieving based on their reported SAT scores. In addition, these students reported studying regularly during most weeks; most had only part-time jobs or no employment responsibilities; and they reported reviewing notes about three hours per week during the semester.

In terms of modality, the iGen STEM students in this study still clearly prefer to handwrite their notes, and this preference persists throughout their first semester of college (see Table 2). The findings of this study are consistent with the recent findings of Morehead et al. (2019) and Witherby & Tauber (2019) who reported that most college students take handwritten notes. It is noteworthy that in now three recent studies, including ours, handwritten notes were the most commonly used notetaking modality, yet other studies found that taking digital notes were more enjoyable and convenient than handwritten notes (Aguilar-Roca et al., 2012; Gose, 2017; Luo et al., 2018). It is unclear what causes the difference between most commonly used notetaking modality (i.e., handwritten) and modality that is most enjoyable or convenient (i.e., digital notetaking). This difference is likely not caused by participants lacking computer skills since participants in this study reported knowing how to download software and had high confidence in their ability to learn to use new software. This reported confidence did not result in an interest to learn new software or the use of specialized notetaking software. This is inconsistent with previous studies (Rue, 2018; Schepman et al., 2012) which found that students preferred the use of specialized notetaking software (i.e., Evernote) to assist with coursework and the assumption made that iGen students' comfort with technology equates with a preference for digital notetaking.

The students in the current study reported employing a variety of different notetaking strategies throughout the semester with abbreviations, highlighting, and diagrams being commonly used (see Table 3). The notetaking strategies reported to be most commonly used by these participants are, thus, visual in nature. This is not surprising since STEM students use diagrams in learning, and iGen students tend to use visual imagery as a learning strategy (Manalo et al., 2013; Shatto & Erwin, 2016). While the use of highlighting and underlining did not change much over the semester, there was an increase in participants using diagrams, perhaps in response to the requirements of their STEM courses. This is positive since the use of visuals within notes is a strategy that has been found to help students engage with learning (Luo et al., 2018; Ramsay & Sperling, 2011).

The effectiveness of verbatim transcription as a notetaking strategy has been questioned in past studies (Luo et al., 2018; Mueller & Oppenheimer, 2014). Approximately 70% of participants in this study reported summarizing lectures in their notes whereas ~50% reported attempting to capture everything their instructors say (i.e., verbatim notes). This was consistent with findings from Bonner and Holliday (2006), who also found nearly fifteen years ago that 50% of students attempted to copy what instructors said verbatim. An objective evaluation of the degree of actual verbatim nature of the notes, compared to what the instructor said, was not assessed as part of this study.

As mentioned in the background, engagement with one's notes (e.g., making flashcards) is essential for true learning to occur (Ramsay & Sperling, 2011). The participants in this study reported

using a variety of strategies that have been associated in the literature with engagement with notes. Flashcards was used by most participants (e.g., ~70% at time one), followed by "explaining the information in my notes" and "draw and label diagrams," both used by ~57% of the sample at Time 1 (see Table 4). This is consistent with a finding from Morehead et al. (2019) that half of the students reported using flashcards. As the semester progressed, slight variations (1-10%) in engagement strategies used were found for most items (see Table 4). Given the decrease in sample size, it is unclear whether these small variations are reflective of a real change during the first semester. Participants reported an increase of ~20% in "create test questions" between the first and third data point which was expected since the latter data point was just a couple of weeks before final exams. A ~10-12% increase was also found in "reviewing notes with a tutor", "drawing and labeling diagrams" and "writing all the information recalled" between the first and third datapoint (Table 4), although "reviewing notes with a tutor" was by far used by the fewest number of participants at any point in time. Graham (2018) suggests that iGen students may have difficulty engaging with their notes, which does not seem substantiated by the self-report engagement rates found in this study. A future study which would analyze objectively the quality of the participants' notes will allow confirmation or refutation of this assumption.

When asked about their confidence with different aspects of their notetaking, participants indicated a fair confidence in their abilities. This confidence was lowest at Time 2, which happened to be the timing of midterm exams, but increased again by Time 3, the timing of final exams at the end of their first college semester. Self-report of the completeness of notes and usefulness of notes to study for exams explained the 16-17% of overall confidence in notetaking abilities.

Related to confidence in notetaking skills, participants indicated whether they intended to improve their notes across a number of parameters (e.g., legibility, helpfulness, accuracy; see Table 6). Few participants were concerned about their notes' legibility (< 20% by Time 2); whereas for most other parameters, ~50% of the sample was interested in making improvements. Time efficiency of notetaking was the exception with 70% of participants at Time 1 reporting that they wanted to be more efficient in notetaking. However, this percentage dropped at each data point, perhaps suggesting that participants were improving their notetaking efficiency throughout the semester. In fact, across all eight parameters upon which participants could wish to improve, there was a decrease in concerns from the start to the end of the semester. This is consistent with previous studies which found that 96% of students stated that their notetaking skills improved during their time in college, as they changed their strategies to meet the demands of their courses (Bonner & Holliday, 2006; Van Meter et al., 1994). The dichotomy found in this study between confidence in notetaking skills and desire to improve notetaking skills, is in line with studies from Whiterby and Tauber (2019) and Morehead et al., (2019) who found that despite having confidence in their notetaking abilities, participants expressed a desire to improve their skills and participate in skill building workshops.

Limitations

The study sample was drawn from a single university with students who are primarily high achieving in terms of SAT scores and come from white college educated families. Generalization to students with other characteristics should be done cautiously. The sample was STEM freshman students in their first semester of college. Although the initial sample size was substantial (n=139), there was attrition at each time point, and some participants contributed data at non-adjacent time points. In addition, the psychometric structure of the questions within the NASUS is not currently known, which precludes the use of summary scores to form grouping variables. However, given the dearth of research on notetaking practices, there is value in providing descriptive statistics over three time periods. Any inferences about the changes in notetaking practices across time-points should be made with caution. Despite this, we see the analysis as valuable from a normative perspective, which may be helpful for researchers and practitioners alike. That is, we present information about self-reported notetaking practices of iGen STEM students that, to our knowledge, was not available prior to our analysis. Finally, while participants were encouraged to be as honest and truthful as possible, it may be difficult for them to accurately report their notetaking practices. The latter limitation is shared

by other studies relying on self-report data. Given the consistency among current and past results, it is not likely that this is a major concern. A study combining self-report and objective measures of note quality may be useful in explaining some of the differences between this study and previous studies.

CONCLUSION

The study found that most iGen STEM students take handwritten notes a majority of the time, which remains consistent throughout their first semester in college. They use a variety of strategies when taking notes such as highlighting and diagramming. They report a higher rate of summarizing lectures compared to attempting verbatim transcription of what is said during a lecture. Participants used a variety of note review strategies with flash cards being by far the most popular early in the semester. Participants appear to employ a greater number of strategies to review their notes as the semester evolves. Participants are reporting wanting to improve their notes across most of the parameters studied, but their wish to improve their notes decreases over the semester. Efficiency of notetaking was the parameter that participants most wanted to improve early in the semester. Overall, the iGen STEM freshman in this study reported engaging in notetaking behaviors that is conducive to increased quality of notes and greater learning. This study does provide preliminary evidence that freshmen STEM students actively adjust the ways in which they use their notes as their first semester unfolds. Future studies could investigate this theory through a well-designed cross-sectional or longitudinal study.

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