European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

DOI: 10.46827/ejes.v8i2.3552 Volume 8 | Issue 2 | 2021

SOCIAL MEDIA USE AND SCIENTIFIC SENSE-MAKING AMONG MATHEMATICS AND SCIENCE STUDENT TEACHERS AT A PUBLIC UNIVERSITY

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Abstract:
Social media and scientific sense-making serve a current and important interplay in the teacher education process. The aim of this study was to understand the application of scientific sense-making practices and competences on social media platforms through the use of the Social Media Use and Scientific Sense-Making (SMSM) questionnaire. The questionnaire was developed, adapted and administered via Google forms and contained three sections: Personal Use of Social Media, Scientific Sense-making and a modified three out of the twelve items from the "Scientific Sense-making Survey- Form B (Monkeys)" (Activation Lab, 2016). A total of 111 student teachers (fourth year and first year MSc students) took part in the survey. The results show that the most frequent and productive engagement is done on WhatsApp (96.4%) and Facebook (75.6%). Leisure activities (over 65%) dominate the use of social media, compared to sharing scientific, technological and environmental issues. In addition, the findings show that despite inconsistencies in perceived self-beliefs in competency, the student teachers have developed sufficient sceptical, questioning and evidence seeking practices. Lastly, there is a general consensus on items that demonstrate scientific sense-making.

Keywords: scientific sense-making, self-belief, social media, student teachers

1. Introduction

There is little doubt that the use of social media has become pervasive in our personal, familial, and professional lives. There is increased reliance on social networking sites as conveyers of information, news, and entertainment. However, some of the information carried may be partial, inaccurate or distorted placing great need for a sceptical and critical approach to messages and information conveyed via social media platforms or the internet. In science education (that entails education in science, mathematics, and

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technology (Rutherford & Ahlgren, 1991), healthy scepticism, critical questioning, and seeking evidence and/or verification are all part of habits of mind that constitute important learning outcomes connected to ability to think for oneself. These habits are related to scientific sense-making.

Cannaday et al (2019) explain that scientific sense-making occurs when the criteria used to determine the best question, best evidence, and best action are in accord with canonical scientific explanation. Scientific sense-making relates to the reasonable connection between one's approach in thinking and acting and scientific practice, judgment or decision making. Fitzgerald and Palinesar (2019) thus align scientific sense-making to the discipline of science. Consequently, when evaluating scientific science-making, the focus is on the reasonableness of a proposed solution and the employment of scientific ideas or models. Odden (2017) suggests that the goal, in confronting a problematic situation, is about 'figuring something out' a viable solution in a coherent, defensible and rationale way. The Activation Lab (2016) defines scientific sense-making as follows: "*Scientific sense-making involves interacting with science-related tasks and text as a sense-making activity using methods generally aligned with science, including: asking good questions, seeking mechanistic explanations for natural and physical phenomenon, engaging in argumentation about scientific ideas, interpreting data tables, designing investigations, and understanding the changing nature of science*" (http://activationlab.org/wp-content/uploads/2018/03/Sensemaking-Report-3.2-20160331.pdf).

It would be expected, at least in the case of science educators and learners, that scientific understanding and habits of minds would be the same ones they deploy when confronted with real life problems, scenarios or issues or in their approach and use of social networking sites. We therefore conjecture that scientific sense-making constitutes an important part of social media literacy and that it is an important learning outcome in science education.

2. Purpose of the study

We conducted an exploratory survey to assess our conjecture that scientific sense-making constitutes an important part of social media literacy and that this constitutes an important learning outcome nurtured through mathematics and science education. We wondered if this was true of our own students undertaking courses preparing them to teach mathematics or natural science subjects at secondary education level. Overall, this study aimed to explore and appreciate social media use and scientific sense-making among mathematics and science teachers at our university, a public university in Zambia. We designed and administered a Google forms survey that helped us peek into the following questions:

1) How frequently and how productively are science and mathematics teachers engaging with social media platforms?
2) Have science and mathematics teachers developed a sufficiently sceptical, questioning, and evidence seeking attitude and scientific sense-making?

3) Have science and mathematics teachers developed any competencies relating to literacy in the use and application of social media?
4) Are teachers' mathematical and/or scientific learning reflected in their expression of attitudes and values, and in scientific sense-making?

3. Description of the survey instrument

A 'Social Media Use and Scientific Sense Making Questionnaire-SMSM' was developed and adapted for administration via Google forms. It was structured in three sections to capture respondents' demographics, personal use of social media, and scientific sense-making. The demographics captured degree level, year of study, specialisation, gender, and age group. The 'Personal Use of Social Media' carried a prompt question "What social media platforms do you use and how often?" It was intended to assess how frequently and how productively they are engaging with social media platforms. To this prompt, respondents were provided with a checklist to indicate from 10 popular social networking sites the ones they used; they could choose 'other' and specify. Second, they were prompted "What do you do on social media platforms?" to which they could respond to 10 activities on the scale from 1-5 where *(1) Never (2) Once a month (3) Three times a month (4) Every week (5) Everyday.* These activities were selected to identify with use of social networking sites for leisure or entertainment, to share information on the environment or climate change, to share information relating to teaching and learning, and to share information on science and technology.

The section 'Personal Use of Social Media' also sought to appreciate whether or not in the use of social media the teachers developed any competencies relevant to social media literacy. They responded to 10 items following the prompt "Do you believe your use of social media helped you to become competent in any of these ways?" They applied the (1) *Not at all competent (2) Barely competent (3) Not certain (4) Competent (5) Very competent.* The competencies related to scepticism, questioning, verifying accuracy and authenticity, objectivity, and integrity. Sample items are: 'I verify accuracy of the information I share on social media' and 'I have integrity when it comes to posting information on social media'.

The last section carried items that helped to assess 'Scientific Sense-Making' among the mathematics and science teachers. In this section we wanted to have some insight into the question: Does their mathematics or scientific training and purported learning outcomes matter in their expression of attitudes and values, and in scientific sense making? First they were asked "What would you do after you receive the following post on your social media group? "*A university student is the worst polluter when compared to a marketeer*". They were presented with 10 action statements to which they could express their agreement or disagreement to each on the scale from 1-5: (1) *Strongly disagree (2) Disagree (3) Undecided (4) Agree (5) Strongly agree.* Example action statements are: 'I would take the side of the majority of members of my social media group who decided

that the statement is true' and 'I would check the source of the information before I can believe it to be true'.

In addition to the above, we slightly adopted and modified three out of the twelve items from the "Scientific Sense Making Survey- Form B (Monkeys)" (Activation Lab, 2016). We adopted three items SSS_Mo1, SSS_Mo2 and SSS_M03. They focus on the scenario whereby Steven, Jessica and Michelle are wondering about how different kinds of monkeys live and survive. SSS_Mo1 is concerned with asking questions to investigate an issue, SSS_Mo2 is concerned with best evidence needed to answer the question, and SSM_Mo3 is focussed on what to do to answer the question. In the Activation Lab version, respondents were given four options that included the one that demonstrated evidence of scientific sense-making. We adapted this by adding to each question two more options: "What does the internet say about how monkeys play?" and "What do members of her social media group say about how monkeys play?" This means that the respondents in this study were presented with six options, with one option reflecting (i) question that is the best to ask to investigate, (ii) best evidence to get to answer the question, or (iii) what to do to answer the question. All other options were not consistent with scientific sense-making.

4. Survey administration and sample demographics

The survey was adapted for electronic administration via Google forms. The administration of the survey was achieved in April-May 2020 during the period when the University was prematurely closed due to the new COVID-19 pandemic. We administered the survey to BSc Mathematics and Science Education Year 4 (current group and the group awaiting graduation), and in-service teachers reading for the MSc. We achieved this by sharing the questionnaire through the class WhatsApp platforms. Completing the survey was voluntary.

The survey secured 111 voluntary responses from the in-service teachers who were studying for a master's degree (n = 44) and pre-service for a bachelor of science (n = 65) in mathematics and science education (2 did not indicate). Of the 111 respondents, there were 67.6% male and 29.7% female, and 2 preferred not to state their gender. Half of the masters group of students responding were completing their first year of taught courses and the other half were in second year of their masters doing their research projects. The bachelors' students representing 58.6% of respondents were mainly fourth year students who were due to complete their degree programmes. Table 1 shows the distribution of respondents by specialisation in mathematics or science education. Slightly over 44% were in mathematics education and the smallest proportion (10.8%) were in physics education.

Table 1: Distribution of respondents by specialisation at BSc or MSc (n = 111)

Specialisation	Frequency	
	n	%
1. Chemistry Education	27	24.3
2. Biology Education	23	20.7
3. Mathematics Education	49	44.1
4. Physics Education	12	10.8
Total	111	100.0

5. Survey results

In a previous section, the purpose of the study was explained. This section presents the results of the survey.

5.1 Personal Use of Social Media Platforms

First, the survey enabled us to gain appreciation of the social media platforms used by the teachers and how frequently and how productively they engaged with or through them. Table 2 shows the distribution of social medium platforms presently used by respondents in the study. The majority use WhatsApp (96.4%) and Facebook (75.6%); 44.1% report using YouTube. Table 2 shows that the other platforms, e.g., Twitter, LinkedIn, Classmates, etc., are not used much. Tumblr is not identified at all.

Table 2: Distribution of social media platforms presently used by teachers (n = 111)

	Frequency		
Platform	n	% / total mentions	% / number of participants
1. WhatsApp	107	34.29	96.4
2. Facebook	84	26.92	75.7
3. YouTube	49	15.71	44.1
4. Instagram	27	8.65	24.3
5. Twitter	21	6.73	18.9
6. LinkedIn	11	3.53	9.9
7. Classmates	6	1.92	5.4
8. Pinterest	4	1.28	3.6
9. Others	2	0.64	1.8
10. Myspace	1	0.32	0.9
11. Tumblr	0	0.00	0.0
Total	312	100.0	n/a

Note: Totals exceed number of respondents (n = 111) because they were allowed to indicate multiple platforms.

Table 2 also shows the total number of times each platform was identified. The most popular social networking sites are WhatsApp and Facebook; they received a total of 34.39% and 26.92% of the mentions, respectively.

In the survey, it was of interest to gain insights into what they did on the social networking sites. They responded to 10 items in response to the probe: 'What do you do on the social media platform that you use?' To this prompt, they were to choose from a

number of responses: never, once a month, every week, and every day with the results in Table 3.

Table 3: Distribution of teachers according to what they typically do on social media platforms (n = 111)

What do you do on the social media platform that you use?	Frequency (%)			
	Never	Once a month	Every week	Everyday
1. Sharing music, photos, or videos for leisure	7.3	25.3	33.3	32.4
2. Share information on developments in science or mathematics	23.4	32.4	30.6	11.7
3. Share issues related to the environment	24.3	36.9	28.8	9.0
4. Share information on mathematics/science teaching/learning approaches	19.8	37.8	26.1	13.5
5. Share information on social events and entertainment	9.0	39.6	24.3	23.4
6. Sharing photos, videos or tutorials to learn some science or mathematics	16.2	32.4	23.4	24.3
7. Share answers, information or research of interest to teachers	24.3	37.8	22.5	11.7
8. Share information on impact of advances in science on people's lives	23.4	41.4	21.6	11.7
9. Posting opinion on a science topic or issue to a discussion forum	23.4	41.4	20.7	13.5
10. Share information on impact of technology on people's lives	22.5	40.5	20.7	14.4
11. Share information on the sustainable development goals	41.4	28.8	18.9	9.0
12. Share issues related to climate change	36.9	40.5	13.5	7.3

Note: Rank ordered by category 'every week'.

Slightly over 65% of the survey participants used the social media platforms for leisure and sharing music, photos, or videos (32.4% every day and 33.3% every week). Assuming that use of social medium platforms every day or every week can be considered as frequent use, Table 3 shows that other than 'sharing music, photos, or videos for leisure' the combined frequencies do not reach 50%. The least frequent use is associated with sharing issues on the sustainable development goals (41.4% never, 28.8% once a month), climate change (36.9% never, 40.5% once a month), and issues related to the environment (24.3% never, 36.9% once a month). Noteworthy too is the fact that only 60% or slightly above 'share information on impact of advances in science on people's lives' or 'posting opinion on a science topic or issue to a discussion forum' (23.4% never, 41.4% once a month), or 'Share information on impact of technology on people's lives' (22.5% never, 40.5% once a month). Their use of social media networking sites appears to be more dominated by leisure activities and less so by sharing on topics of scientific, technological and environmental issues.

5.2 Perceptions on competencies developed

In addition to appreciating how frequently and how productively they engaged on social media platforms, we explored whether or not the teachers acquired any competencies relating to literacy in the use and application of social media. They were asked to respond to 10 items. The lead question asked was: 'Do you believe your use of social media helped you to become competent in any of these ways?' Table 4 shows that over 50% of the participants perceived that they were competent or very competent on 5 out of the 10 items. For example, 74.7% expressed 'awareness that not all information is truthful' (37.8% competent, 36.9% very competent), and 65.7% expressed that they had integrity when it comes to posting information on social media (42.3% competent; 23.4% very competent). The majority also expressed a belief in competency around verifying accuracy of information shared (63.0% competent and very competent) and approaching issues shared with a questioning mind (58.5% competent and very competent).

However, results in Table 4 show that they were not consistent in their self-beliefs about competencies. For example, the number of those responding as competent or very competent to the item "I am questioning the information shared on social media" is only 46.8% compared to the 58.%% who perceived that they approached social media with a questioning mind. Further, 35.2% expressed 'not certain' to the statement "I have my doubts about information shared on social media". They were also divided between the 31% expressing 'not certain' and those expressing 'competent" that "I am researching accuracy of information shared on social media".

Table 4: Perceived belief in competency in using social media (n = 111)

Do you believe your use of social media helped to become competent in any of these ways?	**Frequency (%)**				
	Not at all competent	**Barely competent**	**Not certain**	**Competent**	**Very competent**
1. I confront issues shared on social media with questioning mind	9.0	9.0	20.7	45.0	13.5
2. I verify accuracy of the information I share on social media	9.9	8.1	17.1	45.0	18.0
3. I am questioning the information shared on social media	10.8	15.3	24.3	42.3	4.5
4. I am appreciating scientific or mathematical knowledge and issues through social media	10.8	9.0	21.6	42.3	14.4
5. I have integrity when it comes to posting information on social media	8.1	9.0	15.3	42.3	23.4
6. I have the awareness that not all information is truthful	6.3	4.5	12.6	37.8	36.9
7. I am a debater on the issues shared on social media	15.3	17.1	23.4	36.0	5.4
8. I have my doubts about the information shared on social media	9.0	16.2	35.1	31.5	6.3
9. I am researching accuracy of information shared on social media	15.3	14.4	31.5	31.5	5.4
10. I hold the belief that information posted on social media must be truthful	26.1	19.8	21.6	22.5	8.1

Note: Rank ordered by category 'competent'.

5.3 Scientific sense-making

In addition to exploring the patterns of use of social media platforms, the survey also explored scientific sense-making when confronted with different real life scenarios. Scientific sense-making is concerned with general scientific practices and their proper application in figuring out things when confronted with a problematic situation. In the first scenario, participants were given the task question: What would you do after you receive the following post on your social media group? "*A university student is the worst polluter when compared to a marketeer*". They were given 10 items reflecting different courses of action to which they could strongly agree, agree, disagree and strongly disagree; they could also chose 'undecided' if they could not decide to agree or disagree. Some of the items offered what could be acceptable as an action that is based on scientific sense making. Table 5 summarises the results.

Overall, in Table 5, the majority of participants responded in ways that show agreement to items that demonstrate scientific sense-making. Given the scenario and claim that a university student is the worst polluter, more than 70% agreed or strongly agreed that they would question the statement if true or not (41.4% agree; 29.7% strongly agree), would check the source of information before deciding (38.7% agree, 35.1% strongly agree), and would check for research evidence before deciding (3.2% agree, 38.7% strongly agree). Further, they disagreed or strongly disagreed (62.3%) to taking the side of the majority of the social media group (37.8% strongly disagree, 23.4% disagree). They disagreed or strongly disagreed to the statement that there is nothing wrong "if I immediately say the statement is true" 24.3% disagree, 31.5% strongly disagree).

Table 5: Perceived scientific sense making around a social media group post (n = 111)

Scenario		**Frequency (%)**				
What would you do after you receive the following post on your social media group?: "*A university student is the worst polluter when compared to a marketeer*".		**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
1.	I would question if the statement is true or not.	6.3	8.1	9.9	41.4	29.7
2.	I would check the source of the information before I can believe it to be true.	4.5	4.5	14.4	38.7	35.1
3.	I would be in line with my scientific training to doubt if the statement is true	6.3	12.6	20.7	38.7	17.1
4.	I would look up research studies that have studied university students and pollution.	6.3	16.2	17.1	37.8	20.7
5.	I would check if there is some research evidence to be able to say if it is true.	3.6	10.8	10.8	34.2	38.7
6.	I would wait to see what others in my social media group would say.	12.6	14.4	23.4	33.3	13.5
7.	I would be going against my scientific training to accept this statement as true	18.0	17.1	22.5	27.0	12.6
8.	I would immediately say it is likely a false statement	18.9	20.7	18.0	25.2	15.3

9.	I would take the side of the majority of members of my social media group who decided that the statement is true.	37.8	23.4	17.1	16.2	3.6
10.	There is nothing wrong if I immediately say this statement as likely true.	31.5	24.3	20.7	16.2	3.6

Note: Rank ordered by category 'agree'.

For further exploration of scientific sense-making, respondents were presented with three scenarios in Tables 6-7 depicting three students Steven, Jessica and Michelle wondering about how different kinds of monkeys live and survive. They were to choose the one option they thought was best if they were Steven, Jessica or Michelle. There was one single best option that could be characterised as reflecting scientific sense-making. The results are presented in Tables 6-8.

In scenario 1 'best question', they were given the prompt and question: "Steven wonders if the temperature outside makes a difference in how much monkeys play. Which question is the best to ask to investigate this?" Only 48 out of the 111 respondents (i.e., 43.2%) gave the plausible answer in this scenario, i.e., Do monkeys play more when the weather is hot or cool? This means that the majority (56.8%) chose a question that did not tally reasonably with the scenario given. The questions selected lacked logical merit. A sizable number (30) reflecting 27% of participants chose option 2 which was not hinted in the scenario, i.e., Do monkeys live in areas that are generally hot or cool?.

Table 6: Scientific sense-making scenario 1 'best question'

Scenario 1	**Response Frequency**	
Steven wonders if the temperature outside makes a difference in how much monkeys play. Which question is the best to ask to investigate this?	**n**	**%**
1. Do monkeys play more when the weather is hot or cool?	48**	43.2
2. Do monkeys live in areas that are generally hot or cool?	30	27.0
3. What does the internet say about how monkeys play?	9	8.1
4. Which other animals live in the same part of the jungle as monkeys?	8	7.2
5. Do monkeys play in hot weather?	7	6.3
6. What do members of her social media group say about how monkeys play?	5	4.5
7. Missing	4	3.6
Total	111	100.0

**Best question

In scenario 2 seeking best evidence to collect, they were given the prompt and question: "Jessica is wondering which monkey eats the most. What is the best evidence she could get to answer her question?" Only a third of the respondents (n = 37; 33.3%) identified with the plausible best evidence, i.e., 'She could count the number of things each of the monkeys eat'. This means that two thirds (66.7%) chose options that were not plausible given the scenario. For example, 30.6% would look up the internet and what it says, 13.5% would consult members of the social media group, and 9.9% would "choose a monkey

and count the number of pieces of fruit it eats and compare it to the number of leaves it eats". These responses demonstrated lack of scientific understanding.

Table 7: Scientific sense making scenario 2 'best evidence'

Scenario 2	**Response Frequency**	
Jessica is wondering which monkey eats the most. What is the best evidence she could get to answer her question?	**n**	**%**
1. She could count the number of things each of the monkeys eats.	37**	33.3
2. She could look up what the internet says about the monkey that	34	30.6
3. eats the most		
4. She could post the question to her social group members to	15	13.5
5. discuss which monkey eats the most		
6. She could choose a monkey and count the number of pieces	11	9.9
7. of fruit it eats and compare it to the number of leaves it eats.		
8. She could guess which monkey eats the most.	6	5.4
9. She could ask her friends which monkey looks like it eats the most.	5	4.5
10. Missing	3	2.7
Total	111	100.0

**Best evidence

In scenario 3 seeking the best action, they were given the prompt and question: "Michelle wonders if monkeys like to sit in tall or short trees. What should she do to answer her question? " Less than half of the participants (n = 46; 41.4%) identified with the plausible best evidence, i.e., Put the monkeys in a place with tall and short trees and allow them to sit wherever they want. The rest (58.6%) chose actions that were not plausible and that followed the pattern for scenario 2 on proposed best evidence to collect. For example, 27.0%% would look up the internet and what it says, 10.8% would "put all of the monkeys in tall trees then move them to short trees and see where they sleep the most", and 8.1 % would consult members of the social media group. These responses demonstrated lack of scientific understanding or choices that not relate to the scenario.

Table 8: Scientific sense making scenario 3 'best action'

Scenario 3	**Response Frequency**	
Michelle wonders if monkeys like to sit in tall or short trees. What should she do to answer her question?	**n**	**%**
1. Put the monkeys in a place with tall and short trees and allow them to sit wherever they want.	46**	41.4
2. Look up what the internet says about monkeys and height of trees they like to sit	30	27.0
3. Put all of the monkeys in tall trees then move them to short trees and see where they sleep the most.	12	10.8
4. Post question to members of her social media group to discuss monkeys and height of trees they like to sit	9	8.1
5. Put all of the monkeys in short trees and see if they seem happy.	6	5.4
6. Put one group of monkeys in tall trees and another group of monkeys in short trees and see who eats the most.	5	4.5
7. Missing	3	2.7
Total	111	100.0

** Best action

6. Discussion and implications

The results of this exploratory study are revealing. The teachers were more likely to be using WhatsApp or Facebook for their social networking than any other platforms. Their use of social media is dominated by leisure activities and less on sharing scientific, technological and environmental issues. This tendency is consistent with what has been found elsewhere. Tayo, Adebola and Yahya (2019) in a study involving 850 undergraduate students in Nigeria showed that the students' primary perceived function of social media is socialisation and that the top three social media platforms they used were WhatsApp (97%), Facebook (85%), Instagram (65%) and YouTube (62%). In the USA, Taylor, King and Nelson (2012) found that the typical activity of students on social networks is to "keep in touch with their friends and to share photos" and only a small percent stated that they use social networks to interact with classmates and course content.

It was interesting to explore how they approached messages on social media considering their scientific backgrounds. The results showed that students have developed sufficient sceptical questioning and evidence seeking. While the findings demonstrate a fairly consistent 'stance' or level of development in sense-making, it is important to take notice of certain barriers to sense-making that individuals deal with. Steiglitz, Mirbabaie and Fromm (2017) found that these barriers relate to "*low information value, negative emotions, biased reporting, taking advantage, volume of information, limited knowledge, speed of information dissemination and technical barriers".* These barriers may influence scientific sense-making by recipients of messages and information. However, it is important to observe that mathematics and science teachers in this study express their attitudes and scientific sense-making in a manner that reflects consistency with their scientific training. This is quite important given that their teacher education and professional development is meant to cultivate scientific sense-making and scientific habits of mind. These should transfer to decision making and action as they confront and deal with real life issues in society. Others have stressed importance of practices involving teacher questioning and making connections (Fitzgerald & Palincsar, 2019) while others like Berland and Reiser (2009) have stressed the importance of engaging learners in scientific practices such as argumentation that depends on sense-making, articulating, and persuading. A critical disposition and habit must be cultivated in teacher education and professional development particularly in the face of social media that is awash with information that may be inaccurate, false or misleading. There is therefore an opportunity to use social media platforms for academic purposes, for example, to inculcate a sceptical and questioning mindset, while promoting accurate communication, argumentation, and sharing of knowledge.

7. Conclusion

This studied examined social media and sense-making among mathematics and science student teachers. It showed that the use of social media is dominated by leisure activities with WhatsApp and Facebook as the top preferred platforms. The majority have developed sufficient sceptical questioning and evidence seeking competencies despite inconsistencies noted. Although there is a general agreement on items that demonstrate scientific sense making, there are a number of noted responses where respondents demonstrated a lack of scientific understanding. This evidence points to a need for continuous professional development in social media literacy and sense-making as an approach to learning.

Acknowledgements
The authors would like to acknowledge the use and adaptation of three items from the "Scientific Sense making Survey- Form B (Monkeys)" (Activation Lab, 2016 at http://www.activationlab.org/toolkit/).

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