Views Of Radiation And Radioactivity Found Among Preservice Teachers

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Abstract

In surveys and over thirty interviews, we have probed ideas about radiation and radioactivity held by preservice teachers. Past research has shown that students confuse contamination with irradiation and that their model of half–life includes halving the mass and volume of the decaying substance. Many students believe that nothing is radioactive unless it is exposed to radioactivity, in particular themselves and the interviewers. We have encountered these as well as some other ideas. We expect to create curricular materials based on this information.

Introduction

We have focused on developing curricular material related to radiation. Our eventual goal is to create inquiry–based materials on radiation and radioactivity that involve students as constructivist learners.[1,2] We report here the misconceptions shared by preservice teachers who are students in the OSU College of Education. Research has shown that students taught in traditional lecture forms do not develop an understanding of physics concepts different from their initial common sense conceptions and misconceptions. In order to establish a strong curriculum for the preservice teachers, we have conducted research to discover the ideas that preservice teachers already possess from their schooling and from the media.

We have conducted over twenty individual interviews with preservice teachers focusing on aspects of radioactivity. Past research[3,4] has shown that students confuse contamination with irradiation and that their model of half–life includes halving the mass and volume of the decaying substance. In addition, Prather has identified a valence electron model of radioactivity, the idea that the atomic electrons are responsible for the decay.[5] We have encountered these ideas among many others. For example, many students believe that nothing (in particular themselves and the interviewers) can be radioactive unless it is exposed to radioactivity; students often do not recognize which information they need to answer questions; many students misuse information on mass, mean life, half–life, and decay rate. Many seem to think that machines make radioactivity and that no radioactivity existed until recent times.

Ranking task interview questions were used to elicit interviewees' natural ideas about radioactivity rather than provoking a memorized response.[6] We have found in some simple ranking tasks that students, almost to a person, are unable to recognize environments representing the greatest danger to health from radioactivity. In still others, the perceived danger from radiation depends on the more–is–more idea that the greater the number of radioactive atoms present, the greater the health hazard (regardless of the activity, i.e., independent of the decay rate). Our interview subjects, with little scientific background, have shown a predisposition to identify human artifice and technology as the sole sources of radioactivity and contamination. These ideas and others we have identified will be discussed here in more detail. We then apply this knowledge by creating curricular materials.

What Can Affect Radioactivity?

All students interviewed for this project plan to become teachers. All student names have been changed. We interviewed them to determine their views about radioactivity and radiation. We note that radioactivity, emission of particles by a nucleus of an atom along with a change in identity of the nucleus, is natural and exists independent of human activity but that most preservice teachers believe that only humans are responsible for radioactivity on Earth.

Views Of Human Causation Of Radioactivity Uncovered In A Ranking Task

Sharon thinks that human technology creates more contamination, as she says, "There is some, I think, that will just keep on multiplying, like if you have one element, I don't know which one so I will just say potassium. And then you divide it. You are really giving more power to it to be more radioactive. So in other words, I think there are some elements that it is best to just leave alone. And that they will just die eventually. And then there are some elements that you really should pull away. . . . Yeah that is where I was going too. Some elements, when you divide them then you take away the radioactivity, and there are some elements that when you divide them you cause more radioactivity. But I don't know which one is which, but I believe that exists."

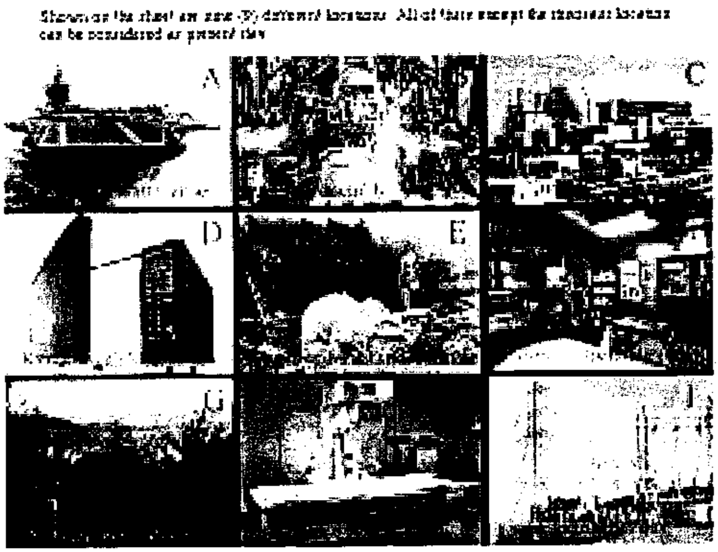

Figure 1: A situation depicting 9 different locations. Students were asked to rank the locations in terms of hazards.

Human influence is seen by many of the students we interviewed. We provide here (See Table 1 on the next page.) a selection of the comments given by students we interviewed about their ranking in terms of hazards of radioactivity (**Figure 1**).

Table 1

Student expressions of radioactivity of various locations of **Figure 1**

Location: Student Comment (different students)

Aircraft carrier: I do not know that much about some of the things, but the nuclear power plant and the nuclear aircraft carrier would to me be great sources of radioactivity.

Assembly plant: The car assembly plant because, again, just seeing all those electrical waves. And I think that equates to radioactivity, too. There is machinery there, so that just makes me think that that could be more radioactive than being away from civilization or age of the dinosaurs.

Nuclear power station: The nuclear power plant I think will be next because, again, the way I think there is just a lot not known about the nuclear, and I guess I just do not understand when I hear it on the news, about the nuclear power plant and how it can affect you.... So I think that there is more to it than what we can see, and nuclear just sounds like a terrifying word to me.

Microwave oven: I am thinking D [is] very high in radiation and very low in radioactivity.... On the table, receiving an x–ray. Microwave ovens I put next, and that is C. And the rest of these things I don't think are very hazardous.... You know, when you are little and your mom says don't sit so close to the TV; there is radiation.

Age of dinosaurs: Well, I probably would go with the past day as the least amount of radioactivity. Just because, well, I don't think there's any electricity around back then.... [A]s far as I understand, most of the radioactivity around today is because we have generated it in our technology. [E (Age of Dinosaurs)] the least because there was not man on the planet making extra, generating, making nuclear power plants and stuff ... (speaking of far from civilization). Just because there is not a lot of stuff that man generates, same theory as the dinosaur thing. I think the least would be right here at the age of the dinosaurs. Because I just think a lot of that area was just more natural it was not touched by humans. I don't know. I think the best way that I can explain it is that I think that after this time period when the dinosaurs lived in humans began to contaminate the land a little bit more. And so when I see this human being, I am thinking something just triggers in my mind, like someone messed with this environment.

Table I Continued

Hospital operating room: I would say hospital operating room next because I feel like I always see the warning signs, like warning radiation. Like maybe there is stuff that is used that has radiation in it. I don't think they have, I mean, I am not really sure how they work. Is it radiation that is even an issue with them? And if it is, it is not that different than radioactivity.

Far from civilization: I would say that G, miles from civilization, may have some, but I don't think it is going to be very strong. 'Cause I am not sure, but I think uranium occurs naturally, and maybe there is some just given off naturally from the Earth. I know that there is natural radioactivity occurring, like in certain, probably, rocks and minerals and things. And those things are going to be present now and when the dinosaurs are around, too. [Next] I would go with miles from civilization, 'cause when I think of radioactivity, I think that of electronics and power lines and appliances and that kind of thing.

X–ray lab: I am thinking this x–ray lab because really what I heard more so when I go to a doctor and get a checkup. Or I have had x–rays before and they always put, this something over you to cover vital organs or whatever. And so I just think that that is the most. You always have to wear lead gear when you are getting an x–ray. I would guess H first. . . . No lead things, no nothing. I would think that this is probably the greatest, the x–ray.

High tension wires: Well, the first thought that comes to my mind is supposedly those people who live near high–tension electrical wires, that they are receiving doses of radiation. I don't think you would be able to build houses right next to them or whatever if they did. I think there would be more of a concern if they had a lot.

Does How Radioactive Something Is Depend On How It Is Produced?

Radioactive decay is a random process independent of human influence. Viola seems to think, on the contrary, that nuclei can be forced to decay. Hilda thinks about a beta decay, "By taking out an electron and an antineutrino, does it deplete the radioactivity, can it render something actually nonradioactive? That can't happen, can it?" She decides the initial radioactive state and the final state have the same level of radioactivity: "I don't think that the electron is radioactive or the antineutrino is radioactive. And therefore there would still be the same amount, unless somehow by removing those it could reduce its radioactivity or make it not radioactive." She also thinks that the decay product can be more radioactive than the initial radioactive element: "It will have more per you know its density, so if you have a smaller amount of this it will have the same amount. I mean it looks like a smaller amount because that has left it. So they might have the same amount, but this would have a higher amount for its mass or density or something like that."

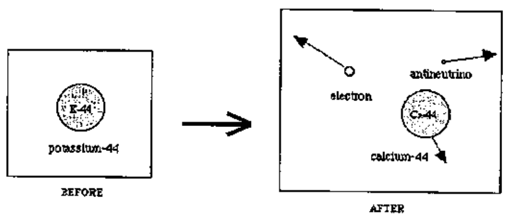

Figure 2: A decay process: potassium–44 decays to calcium–44 with emission of electron and antineutrino.

Sharon was shown a picture of a decay (Figure 2, above). Asked which was more radioactive, she replied, "I would say the before, the potassium–44, because it is just in its natural radioactive state. It is almost like I feel like a scientist. You have to de–radioactivate, so it is like, so pull away some of the radioactivity or it will stay hazardous if we don't touch it." She believes, from this quotation, that we humans can change radioactivity, while scientists understand that no human agency can affect a random process. Looking at another such decay process, she reinforces this notion: "If it is touched by humans and divided and pulled out from and all that, it decreases the radioactivity."

Student Ideas About Radioactive Decay And Half–Life

Radioactive decay is problematic for these students. Physicists define radioactive decay as a change in the nucleus of an atom that results in emission of a decay product and a change in the identity of the nucleus. In most cases, the atom does not change the number of electrons it has. Electron capture is an exception.

Viola seems to have a fair grasp of this idea. She says, "I think it has something to do with something that is unstable, either because it has lost something that is critical to the atom, and I don't know if that is a neutron or an electron. Um, maybe a proton. I am not really sure, but it has lost something. And it is trying to—everything in the universe is trying to—establish equilibrium. So it is giving off. This is so hard to think because I never think about it. Um, it is, you know, reacting to establish equilibrium. And while it is doing that it is giving off radiation which I am not really quite sure what. I know what it does, but I am not really sure how that works." On the other hand, here's what Sybille has to say about decay. (Below, in all cases of interviews, "S" means student; "I" means interviewer.)

S: When you say lose 10% of the atoms every day, then you mean they turn into another type of atom because they are losing things electronically? Is that what you mean?

I: They are losing something. We could probably turn it around and ask what you think is happening.

S: Well, they are losing electrons, I think. That is what I understand.

Of course, Viola later also says electrons are lost in decays: "My thinking was that this would be more stable. . . . I mean it would tell me like, if I knew what that was, maybe I knew if this is losing or has gained an electron or something like that." Apparently there are many sources for their ideas about this part of physics. Perhaps Sybille like Jill gets her information in all the wrong places: "I just saw *Who Wants to be a Millionaire* last night, and they were talking about half-life, but I don't remember what they said about it."

A different student said, "Well, if you have a greater amount at the beginning, then it slowly starts to decline, and then, all of a sudden, it goes down steeply, and then it levels off." This is shown on the left diagram of **Figure 3** on the next page. He goes on: "I think, the only way that could happen is if somehow there is an interaction between the atoms." Actual measurements show the pattern of the graph on the right of Figure 3.

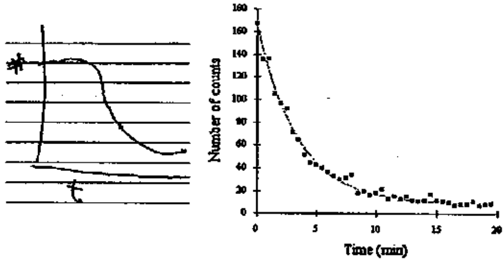

Figure 3: Left: Student's view of a decay curve. Right: A lab measurement of a decay curve.

Does Half–Life Mean Half Of Everything?

Prior research suggested that people think that the term half–life means halving the mass and volume of the radioactive material.[3–5] We saw this view as well, as the following excerpts show. One student said, "The sample would, like you said, have some volume and some mass, and then after one half–life, you would have half the number of molecules. And so how that corresponds to mass and volume, well, you would have half the mass I suppose. . . . As far as volume goes, this would have half the initial volume, too." Another student drew a picture and described what she was doing: "The top, fairly large top circle, I choose carbon–14, and down arrow to a circle that is smaller than that, approximately half the size, still a carbon–14, with a designation for the half–life. So for every half–life the atom is decaying, [it loses] half of its mass. . . . And then it would just continue on another half–life, until it decays down to zero."

More students opted for the "half means half" view. One said, "Based on the term half–life, I would say half. You would have half as much of there, to produce half as much radioactivity." One student raised an (inappropriate) analogy: "So after a thousand decay processes, half of your little tape–recorder there is going to be gone. And so, I am trying to figure out, if there is going to be, still be, a thousand decay processes coming from half the substance, or if there will be less decay processes because there is less substance."

How Radioactive Is The Substance?

The activity of a substance is the number of decay products emitted per second by a substance. This is a measure of the radioactivity of a substance. The activity depends both on the number of radioactive nuclei and the mean life τ (or equivalently, the half–life T, or the decay rate λ; these are connected by $\lambda = \lambda/\tau$, $T = \tau \ln 2$).

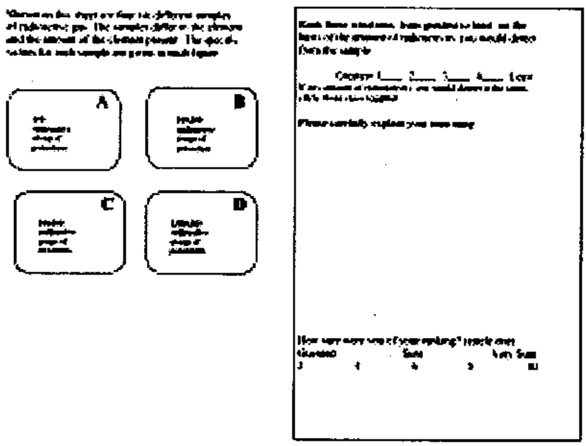

Figure 4: Example of the ranking task assigned to students. The examples were chosen so that C is always the most radioactive. C is followed by D, B, and A in descending order of number of radioactive atoms.

We gave students pictures, such as shown in **Figure** 4, with four variations on the theme. We first asked students whether they could rank the radioactivity of several samples when given inadequate information. The first figure indicates no information but the type of radioactive nucleus (potassium–40 and strontium–87). No one can know how radioactive such an atom is without access to additional information (mean life {given using samples uranium–238 and plutonium–242}, half–life {given using samples uranium–235 and carbon–14}, or decay constant {given using samples plutonium–239 and phosphorus–40}). The four figures were essentially identical to **Figure** 4 and all but one was introduced with one of these pieces of information necessary to allow determination of which had the greatest activity. **Figure** 5 shows one of these possibilities.

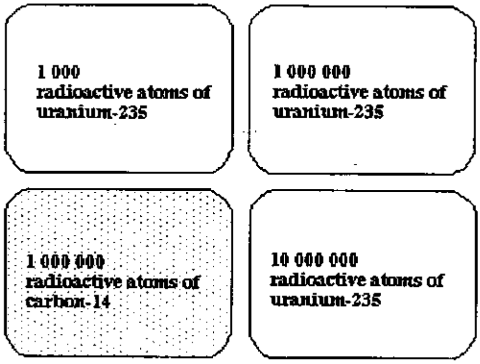

Figure 5: The version of the picture corresponding to supplying information on half–lives.

Jill had trouble with distinguishing how radioactive something was. She says, "I am thinking that it said that carbon–14 had a half–life of 5,730 years and that is quite a difference from 700 million years, and uranium for some reason is clicking more with more as far as being a radioactive element. So I think any of the uranium would be more radioactive than the carbon–14. I don't know if I am right or not." She goes on to say in explanation: "I would think that if it had a longer half–life, that that would mean that it would be, the half–life would be how radioactive it could be."

Sharon thinks that "the longer it [a radioactive element] lives, the more radioactive it will be." A little later in the interview, we find her explanation of her choice:

S: Um, what made me make the different choices since the uranium–238. I mean from when I read, okay, what made me make that choice is not really mean life or half–life. But what I went from was the element the number that was next to it and how many years. So in my mind I put the element number in years if that is longer. And if this is higher than this one here, then this is going to be more radioactive. I really just, to simplify. I am sorry. I went with this reading, and I looked at number of years, and if this number was higher and it had more years, then it would be more radioactive. I did not really look at mean life or half–life at all. I just looked at the reading to see the number of years.

I: So in neither one of these did you really look at the mean life or half–life. You are just going from the number of atoms and the number here. This number like 238 for the uranium and 42 for the plutonium. Or over here, 235 from the uranium and 14 from the carbon.

S: That's right. That is exactly what I did. I did not look at mean life or half–life because, to be honest with you, I do not totally understand those terms.

I: What, so you say you do not totally understand. So, can you tell me a little bit about the understanding that you do have of those terms?

S: Um, let me start with the half–life. Okay, from what I recall from my college, my undergraduate, whatever. The half–life is, like, scientists have given the normal life of an atom. And I do not know exactly what that is. And when they say a half–life is half of that standard that has already been set by scientists. The mean life, tying it into math, is, like, the average number of years that element will be around. An average life, or half of the standard that has been set by science.

Viola says something similar to Sharon and Jill: "It seems like if it is something unstable and it is trying to establish equilibrium and it is giving off this stuff, this radioactivity as it is trying to establish equilibrium. For 6.5 billion years, in terms of something that is giving off radiation and trying to establish equilibrium, and it only takes 540,000 years. I would think I don't know though because maybe it is giving it off faster. I don't know, but I would guess that the one, um, that has the shorter life, that would establish equilibrium faster would be less radioactive." Later in the interview, she expands on this theme, saying, "I am trying to figure out if something with a half–life of 700 million years means that it is giving off the same amount of radiation. Assuming it has a smaller half–life, it is just giving it off slower. Or wait, does that make sense? Yeah, it has the same amount like as something else, but 700 million years means it is giving it off slower or if it means that it just has so much more to give off. Does that make sense? . . . So radioactive carbon–14 has a half–life so that is going to be the least. So I am going to put that that has the least amount of radioactivity because it is going to, its half–life is so much smaller that it will be gone faster, so it is less radioactive."

Jill has outside information, saying, "You know what? I know that carbon–14 is just not a bad radioactive thing because it is in your system. It is in all living things to a certain extent, so I am just going to say that all of the uranium stuff is way more radioactive and that would go in descent of like quantities."

Of course, perhaps we were psyching the students out by trying to be helpful. We gave them a set of pictures to look at (referred to above). One set of radioactive gas atoms was conspicuously colored differently. Hilda says, "I think I was looking for the easiest way to get to the answer, which was disregard the extra information and go back to just the visual cues that were there."

Janice is reasonably certain about how to interpret the most or least radioactive, "They were all potassium–40. So they are all like the same level of radioactivity per atom, so that it would mean that if there are more atoms present that there would be a greater amount of radioactivity. . . . Common sense would tell me that there would be more radioactivity if there were more radioactive atoms. So I guess I would go with D being the greatest." All the students express this idea, very reasonably, about the three similar types of atom. However, Janice thinks that "one atom of radioactive plutonium is going to be as radioactive as 5,000,000. See, that is what I am trying to figure out. I mean if it is radioactive, it is radioactive." Hilda realizes she needs more information, saying, "I would just make a logical guess about this, D being more because it says it is a million. Now I don't know where strontium–87 would fit on that. I would just, I wouldn't even, I mean for me to put anywhere in the ranking would be completely random."

Viola and Sharon had the greatest number of ideas about what makes something more or less radioactive. Viola expresses three separate ideas. She says, "I don't know the number of neutrons that potassium and calcium normally have in their atom, but I think the one that has an imbalance between their protons and neutrons would be the one that is most radioactive. . . . I would guess it would be the calcium. . . . I am thinking that potassium, for some reason, would not be radioactive. I am thinking that maybe uranium would be radioactive. So, I guess if I had to, to put it in order, I would put it from the greatest number."

Finally, she reveals that she had been "assuming that the 87 had something to do with mass number and it would be heavier or denser [and] would have more radioactivity to emit. . . ."

I: So in terms of interpreting danger. The half life or mean life, whatever it is those things may be, those really have no effect on the amount of radioactivity, those things have nothing to do with it?
S: Right, I don't think so.

Another student, asked what would be expected 600 years from now if he checked on a 2–gram sample of carbon–14, replied in agreement with Sharon's point:

S: The same.
I: Maybe like 200 million years from now?
S: Probably the same. . . . I guess. I just don't have any reason to think that those carbons are going to leave that pencil. Or those radioactivity carbons, or whatever, to leave that pencil. Just over time.

Sharon says, "My gut feeling is to go with, to look at the largest number here [mass number] and then rank it from largest to least. . . . I recall that the smaller the [mass] number, it seems like the more radioactive it is." Later she thinks in a similar way: "The 235 is that element lives longer. And the 14 lives shorter, so I am thinking, too, that the longer it lives the more radioactive it will be. . . . After reading this here, what I am thinking here is that I am still looking at numbers again [mass number]. But this is smaller, and it lives longer. And then this is larger, and it does not live as long. It dies off faster. So I am just feeling good about reading that. I don't know it is helping me to think about this number and how many years it is around."

In interpreting mean life, Viola expresses this view: "I would want to say the least, and that is 50 and that is uranium, and uranium has a really really long lifetime . . . . So I would say that would be more radioactive, and then plutonium, I think, and then I would start to go by the amount [the number of atoms]." Janice reasons: "Maybe the plutonium will be the most radioactive because it decays more quickly than the uranium, which is what I thought earlier on one of the other ones." Later she is unsure, asking, "Does this mean that the uranium has more stuff to give off so that it takes longer, or the stuff that it gives off goes away slower, but it is the same quantity of stuff, of radioactivity?" Janice explains why a longer life will cause more radioactivity: "I am thinking that, like with nuclear waste and that sort of thing, just a tiny amount can do such, well, it lasts forever. Well, it does not last forever, but it takes forever to break down, and they can't figure out where to put it because it is still radioactive." This realization is quite a mix of informed and uninformed knowledge. She also says, incorrectly, "If it has a longer lifetime, then it must be more radioactive, just because what I heard about waste."

Sharon compares the hazard of radioactivity from plutonium and its decay to the product uranium: "This number is smaller than the plutonium, and so that is why I said this would be greatest because it is going to live or be around longer than the plutonium here."

Viola had quite a bit of difficulty interpreting the decay rate: "Radioactive phosphorus is one of them, and 5.1×10^{-3}. I guess would be, smaller, larger, it would be larger number than plutonium. So I am thinking that plutonium decays slower. Let me see. That would be nine, so that is going to be a smaller number. So that means that it takes a shorter number in that amount of time to decay. So I will say that plutonium takes the shorter amount of time to decay because I was thinking that 9.1×10^{-13}, wait a second, a smaller amount per second, and then this would be a bigger amount per second. So then I need to switch that, did you follow. . . . I was thinking that 9.1×10^{-13} was related to seconds. Not the amount that it decays. So this decays a larger amount per second than the plutonium, the phosphorus does. Okay, well, we will just say that—um, so shorter time to decay for the phosphorus." Sharon says, "5.1×10^{-3} per second is smaller than the number 9, phosphorus is decaying faster than plutonium. If it's decaying faster, it's more radioactive, that's what I'm thinking."

Janice originally says, "It is still going to, this one will run out the fastest of radioactivity just because even though you have less atoms, like if you have 500 atoms of plutonium, or 5 million, it still takes each of the atoms the same amount of time to decay." Janice has been able to change her ideas and now thinks, correctly, "Just from this information up here, like the 0.005 per second, huh, that maybe the phosphorus is the most radioactive because it is decaying much more quickly, but it would also be around much less longer. I would think the radioactivity would [decrease, based off of ranking] because it goes away so fast . . . not as many atoms would decay per second compared to the phosphorus–40. Based on the number, right, because I don't know if it is just the way I am reading it, because they are all radioactive atoms, maybe different materials. But they're all radioactive and just the amount I guess makes the difference. And so I am going to put the greatest at the million dot, million radioactive atoms. And then put B and C together, because they are both 100,000. And then put A because it is only 100. And I don't know if strontium or potassium makes a difference but it says 100,000 radioactive atoms."

Other Issues Investigated

We looked during our interviews at student assessment of the effect of temperature, the state of matter (solid, liquid, gas), and surface effects. Physicists know that they cannot affect radioactivity, cannot make something decay. Neither can they prevent decay. Decay is a purely random process. The nucleus's condition is unaffected by physical conditions that determine the state of matter. Whether an atom is on the surface or not does not affect the nucleus.

Temperature

We attempted to get at this aspect of student understanding by asking students to rank the radioactivity represented by different situations involving different masses and different temperatures (**Figure 6**). Greater mass implies greater activity, but temperature has no effect at all on activity.

Many students think temperature does have an effect. One student said, "I am sure there has something to do with temperature, but I am not sure. I am not sure what, whether or not if it is colder than there is more radioactivity detected from it or if it is hotter than there is more, it should give off more radioactivity." For another, "I would think that when it is cold . . . when it is hot, it is more radioactive. Just because, like, hot temperature makes things move around more. Like in air when

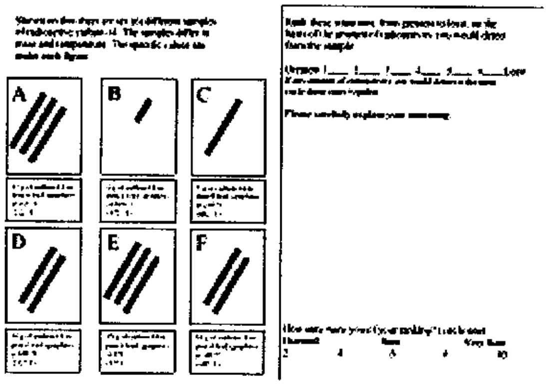

Figure 6: Comparison of effect of temperature on radioactivity when different amounts of substance are present.

the air is hot the molecules move around more. And, um, so I think that it would give off more radioactivity if it was hotter." Another student is more uncertain: "See, I don't know if it, like, freezes. If radioactivity freezes so at the South Pole, they probably still have like radioactivity, even though it is really, really cold there. So maybe it doesn't freeze. And in the core of the Earth, it is really, really hot, but I don't know if they have radioactivity there. So I would think that probably that amount is more important than temperature. But if it is just between temperature and amount and the temperature is higher, then I am going to put A (higher temperature, equal mass) as the greatest."

State Of Matter

As long as the amount is the same, there can be no difference in the amount of activity. We gave students a ranking task involving the physical state of carbon (**Figure** 7).

The students generally did think that the physical state of the atom did affect the radioactivity. One student said, "I would reason that they would be kind of with, in the same, radioactivity because they are the same state . . . and then what's in gases are either going to be on one side of those or on the other side of those. And they probably all have the same amount of radioactivity and that they would all be the same. But once again those temperatures probably mean something, maybe, but

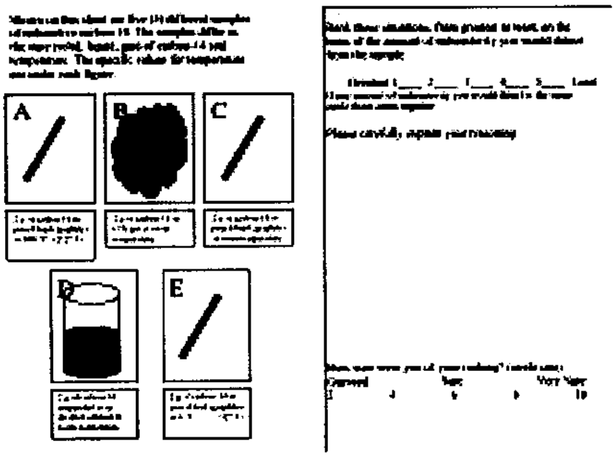

Figure 7: Comparison of effect of temperature on radioactivity and whether the material is solid, liquid, or gas. The amount of material is the same in every instance.

the phases may not mean anything."

The gas phase was a popular choice for affecting radioactivity. One student said, "I am going to say that gas, in its gas state, it would let off more radioactivity than in its solid state. . . . Because of the whole thing, where I was saying that gas is more volatile, and, um, it's . . . I think when it is in the solid state, it can't move around as much. So it's not as radioactive, because when it can't move around. It can't, like, when it moves around and bumps into each other. It releases more radioactivity." Another said, "I think that it probably is affected by whether it is solid, liquid, or gas because it seems like when they have, like, explosions at Chernobyl and stuff the threat is, like, when it is out in the gas."

Student Views Of Surface Area Effects

One student stated that radium decays faster in pitchblende than in a pure sample (which it does not) "[b]ased on, which I don't even know if it applies, but when I look at other things, based on the surface area, with it being scattered you have more exposure rather than a chunk." Another student believed that there are more decayed atoms on the surface than in the center of a sample (there are not), saying, "I think, just based on sort of what I said already, if it is losing something, it is easier for this to lose something to the environment."

Yet another student elaborated why internal atoms in a sample decay quicker (they do not), saying, "I am just thinking, that . . . when it radiates particles, usually, those particles have lots of energy. And I am thinking that since they do have a lot of energy, if they hit another atom, they could somehow disturb that atom, especially if that atom is already unstable. They might, like, kind of, have an influence on them, make it more likely to emit something itself when it collides with a high active particle, that is just what I am thinking of."

V. Conclusion

Many of our preservice teachers have interesting but incorrect ideas about radioactivity. We already know that much media information is biased and/or incorrect, as can be seen from student comments referring to media above and Ref. 3.

Having identified some of their ideas, we have a better basis for making materials that could help fix their misunderstandings. A draft set of curricular materials created to address many of these concerns may be found at Ref. 7. In our curricular materials, we have, for example, addressed the notion that radioactivity is due to human influence by having students carefully measure background radiation, see it is the same at different locations within a classroom, and determine the uncertainty in the background count rate. Something can then be determined to be radioactive when its count rate exceeds the background rate by more than the uncertainty. There are also other materials available to help students and teachers understand radioactivity (Ref. 8).

Future educators who leave a university with misunderstandings about science processes as well as false "facts" have a great likelihood of perpetuating them. Our research efforts are an attempt to prevent this misunderstanding by working to provide an effectively designed research–based curriculum to meet the needs of preservice elementary school teachers. That is our next pressing job.

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Biography

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