Exploring the influence of the mass media on primary students' conceptual understanding of genetics

[1]J. Donovan* and G. Venville

Graduate School of Education, University of Western Australia, Crawley, Australia

(Received 4 April 2011; final version received 21 April 2011)

Abstract

The new Australian Curriculum ignites debate about science content appropriate for primary school children. Abstract genetics concepts such as genes and DNA are still being avoided in primary school, yet research has shown that by age 10, many students have heard of DNA and/or genes. Scientific concepts appear in the mass media, but primary students' exposure to the media and the potential influence it has on their understandings is a neglected area of science education research. This study explores the conceptions that Years 5-7 students in one Australian school hold about genes and DNA and compares that with their levels of exposure to the mass media. Quantitative and qualitative data from detailed media questionnaires and in-depth interviews with 25 children were examined for any indication of a relationship between media exposure and knowledge of genes and DNA. Findings indicate television was the participating students' major source of information about genetics, but generally, as knowledge about genetics increased, so did the incidence of misconceptions.

Keywords: primary science; science conceptions; genetics; genes; DNA; mass media; television.

Introduction

In 2011, each Australian state and territory operates its own curriculum. In science, all curricula have similar content strands covering the disciplines of physics, chemistry, biology, and earth and space sciences, but differ with regard to when content should be taught and learned. For example, Tasmania introduces cells in Years 5-6, Queensland and Western Australia in Year 7, New South Wales and Victoria in Years 7-8, the Australian Capital Territory in Years 8-9, and South Australia in Years 8-10. Discussion of cells precedes DNA, genes, and inheritance, with these topics never addressed before Year 9 or 10. The new Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority [ACARA] 2010) lists cells in Year 8, and DNA and genes in Year 10. The United Kingdom's national curriculum is under review and the Qualifications and Curriculum Development Agency (QCDA) will close in late 2011, but the existing curriculum shows cells and the concept of variation being influenced by both heredity and environment in Key Stage 2 (Years 3–6, ages 7–11), and genetics in high school. In the USA, the National Academy's *National Science Education Standards* (1996) placed simple ideas about heredity in levels 5–8 but left cells and genetics to levels 9–12. More recently*, Benchmarks*, from the American Association for the Advancement of Science (2009), introduces single-celled organisms and inherited transfer between generations by end of fifth grade, cells and simple genetic explanations in levels 6–8, but recommends waiting until students understand molecules (levels 9–12) to introduce DNA. In contrast, research indicates that students have often

[1] Corresponding author. Email: jenny-donovan@hotmail.com

heard about DNA and genes and hold ideas about what they do, long before they reach high school (Springer and Kiel 1989; Venville, Gribble, and Donovan 2005). This body of research raises two important questions: firstly, a question about the appropriate time in the curriculum to start formal instruction on genetics-related concepts and, secondly, a question about where young students learn about genes and DNA if not from school?

The curricula discussed above adopt Piagetian principles, avoiding abstract concepts until the ages of 14 and 15, when students are considered more likely to be able to think in abstract ways consistent with formal operations. Yet for some years, research has demonstrated that students are better able to develop abstract thinking capacities by being exposed to situations requiring them at earlier ages, having such thinking scaffolded for them (for example, by judicious use of models) and building layers of knowledge and thought through a spiral curriculum (Bruner 1960; Willingham 2008; Springer 1999). In particular, the National Research Council (NRC 2007) strongly advocates taking science to schools by moving away from Piagetian principles and towards the development of learning progressions. These are defined as 'descriptions of the successively more sophisticated ways of thinking about a topic that can follow one another as children learn about and investigate a topic over a broad span of time' (NRC 2007, 213). Consistent with these principles and with research demonstrating student interest and exposure to ideas about genetics at primary school ages (Donovan and Venville 2006), Duncan, Rogat, and Yarden (2009) developed a learning progression for genetics commencing at Year 5. Evidence exists that the vocabulary of genes and DNA was successfully taught to students as young as 7 years old using a carefully developed, age-appropriate model (Donovan and Venville 2005; Venville and Donovan 2007, 2008).

The cited research collectively demonstrates that primary aged students can deal successfully with foundational understandings of DNA and genes and that their interest in these topics demonstrates a need to know that facilitates learning. It is not proposed that students learn everything about genetics at primary school, but rather that grasping the key idea that genes, made of DNA, control the body's function, etc. should help them cope with complex genetics information in high school and to understand and explain the world around them. Research (e.g. Lewis and Kattman 2004; Lewis and Wood-Robinson 2000) has shown that the current 'one shot' approach of teaching all genetics information when students are about 14 or 15 years of age is producing neither sound understandings nor a scientifically literate population. There have been other recent calls to 'overhaul our outdated genetics curriculum' (Dougherty 2010, 218). In a century described as the age of genetics and genomics (Feetham and Thomson 2006; Brill 2008), teachers are failing to prepare their students for future life if they do not complete school with the essential knowledge and understanding to make informed genetics decisions on a personal and/or political level.

Prior research also established that students in late primary and early high school may hold a number of misconceptions about genes and DNA, particularly the idea that DNA's only function is the solving of crimes (Donovan and Venville 2004). Responses to this research suggested students learned this 'from the media', specifically television (TV) programmes (referred to as 'shows' in Australia) such as CSI: Crime Scene Investigation (CSI). A measure of 'blame' was attributed to the media, which sparked our curiosity. Is this blame justified? Are students really learning about these science concepts from such mass media sources? If so, what can educators do about this? The research presented in this article is part of a larger study designed to explore these very important issues. Specifically, the purpose of the case study reported here was to explore the relationship between primary school students' understandings of the concepts of genes and DNA and their experiences of the mass media in an area with reduced exposure to crime shows (particularly CSI). For this reason, this study was conducted in one school in a remote town in the state of South Australia.

Conceptual framework

To frame the research exploring the relationship between the mass media and students' understandings of genes and DNA, a conceptual framework was constructed by drawing on the literature in two specific areas: (1) the influence of the mass media on people's understandings of phenomena and (2) students' conceptions and misconceptions of science. No overlap between these bodies of literature that specifically examined how the mass media influences the conceptual development of students in science was found.

Mass media influence

A large body of literature examines the influence of the mass media on adults. Of relevance are the reports of a 'CSI effect', relating the propensity of juries to acquit or convict a defendant depending on whether they watched CSI or not. Whilst studies such as the Maricopa County Attorney's Office (MCAO) Survey Report (2005) and Shelton, Kim, and Barak (2006) disagree concerning the precise nature of the 'CSI effect', they agree that jurors who view the show are influenced into expecting more evidence of a scientific nature to be presented at trials. This finding demonstrates a lasting effect of the show upon some viewers, attesting to the impact of the material it covers.

Media literature concerning children and school age students focuses on attitudes and behaviours such as body image and eating disorders (Tiggemann 2004; Field et al. 2001). One cognitive area of research concerns TV's influence on the development of reading skills (Rice 1983; Naigles and Mayeux 2001). Schmidt and Vandewater (2008) found that viewing educational TV was linked positively with academic achievement, whilst viewing entertainment TV was linked negatively with achievement, but these researchers did not examine conceptual development in relation to any particular concepts. Two substantial metastudies of the influence of TV on children (Van Evra 2004; Pecora, Murray, and Wartella 2007), did not refer to research about TV's influence on students' scientific conceptions, yet articles describing benefits of using media in science teaching appear to assume that students learn from exposure to the mass media (Berumen 2008; Thier 2008). No literature was found exploring the influence of the mass media on concept development in medicine, geography or the law, areas frequently the basis for TV shows. The dearth of literature exploring the links between the mass media and conceptual development in any specific area signifies the important contribution this current research makes to the literature.

Students' misconceptions

Throughout this research, students' ideas about science that do not align with those of scientists will be called misconceptions, in common with Barrass (1984) who wrote of mistakes (errors), misconceptions (misleading ideas) and misunderstandings (misinterpretation of facts). This term is still current, for example, Allen (2010) published a book on misconceptions in primary science. This is a considered decision, intending to highlight the possibility that these ideas have arisen from either misinformation received, or mishandling of accurate information as the students have processed and incorporated it into their conceptual frameworks. The thrust of this research is to explore acquired knowledge, rather than intuitive ideas that students have formed on their own. Students must hear the word 'DNA' somewhere. What is of interest in this study is where they heard it, and how the concept of DNA has been constructed in their minds. Some of these misconceptions could also be termed misrepresentations, in that their inaccuracy stems from their incompleteness, rather than incorrect science.

Berthelsen (1999) noted that students did not understand the relationship between DNA, genes and chromosomes, and that some believed that daughters inherit most of their characteristics from their mothers, and boys from their fathers. Donovan and Venville (2004), Mills Shaw et al. (2008), Lestz (2008), Lewis and Kattman (2004), Lewis and Wood-Robinson (2000) and Chattopadhyay and Mahajan (2004) collectively surveyed a range of age groups from primary students to adults and found these and other key misconceptions. These misconceptions include ideas that genes and DNA are different entities with one promoting familial resemblance, and the other responsible for uniqueness. Some students believe that DNA has no biological function but exists only to help solve crime. Other difficulties include how genes are expressed and translated into visible features, and that different amounts of DNA/genes are inherited from different parents (generalised far beyond the fact that the Y chromosome of males is slightly smaller than the X chromosome of females). These ideas are critical to their future understandings of genetics.

Methodology

Design

A mixed methods design, with both quantitative and qualitative methods of data collection, was considered optimal for several reasons. First, the lack of existing literature concerning the influence of the mass media on conceptual development resulted in this research being exploratory (Ragin 1994; Trochim 2006 Types of Design). Secondly, the nature of both the research and the researchers suited the pragmatic worldview, and according to Creswell (2009), pragmatism lends itself to the use of both qualitative and quantitative methods in order to provide the best understanding of a research problem. Finally, the breadth of the research questions being investigated required the use of both methods to achieve efficiency and depth. A summary of the specific research questions and the methods used to collect and analyse appropriate data, are shown in Table 1.

Table 1: The research questions and corresponding methods of data collection and analysis

Qn #	Research Question	*Methods of data collection and analysis*
1	What level of exposure to the mass media do participating Year 5-7 students report?	*Media questionnaire about students' media exposure; transcription, coding, collation and quantitative analysis of data*
2	From what source do the participating students believe they have learned about genes and DNA?	*Semi-structured interview; coding and scoring of data*
3	What are participating students' levels of conceptual understanding in genetics?	*Semi-structured interview; coding and scoring of data*
4	What misconceptions do participating students have about genetics?	*Semi-structured interview; coding and scoring of data*
5	What links can be drawn between media use and participating students' conceptions?	*Comparison and search for patterns in all data. Secondary search for confirming and disconfirming data.*

The research school context and sample

The study was conducted in a town of around 15,000 people, and, being 670 km from the South Australian state capital, Adelaide, it is classified as remote. This area was selected for its reduced access to certain sectors of the mass media. The chosen school is a new private school, in its second year of operation, with 221 students (K-10). From the My School[1] website, the socio-economic status of the school is expressed by an Index of Community Socio-Educational Advantage score of 1023 (SD¼100), close to the national average of 1000. Students from Years 5 to 7 (ages 10–12 years) were asked to participate in the study, because the findings of Donovan and Venville (2006) showed this age group is likely to have heard of DNA and genes. Forty-three students consented to participate in this research. All these students completed the media questionnaire and 25 were interviewed. Only data from the 25 interviewees are included in this article, because a full set of information was available about each student.

Methods of Data Collection

Two methods of data collection were used; a media questionnaire and an in-depth interview (Table 1). The media questionnaire included six forced response-type questions about how often participating students accessed eight different types of mass media, how long they typically spend each time they access a media source, favourite TV shows and characters, and shows relevant to the research questions such as crime shows and those connecting family relationships, etc. Demographic information was collected through the questionnaire and included rising and bedtimes to assess their active hours and to crosscheck against shows they admitted to watching. Questionnaire construction was guided by Martin (2006) and Willis and Lessler (1999). Special care was taken to pitch the language to the target ages (ages 9-12 years), to give students adequate room to write their answers (A3 paper used), and to make quantities specific, non-overlapping, and easy to estimate. For example, the 'how often do you use each media type' question used 'every day, 2-3 times a week, once a week' and so on up to 'once a year' rather than vague words such as 'rarely' or 'often'. This also allowed data to be weighted to reflect an annual usage (see data analysis). The researcher supervised the students as they completed the questionnaire and answered questions, clarified requirements, and reminded students to fill in all the answers. This avoided the usual problems with questionnaires of poor response rates and incomplete items. Administering the media questionnaire before the interviews enabled the researcher to follow up confusing or contradictory responses and correct simple errors such as writing today's date instead of their birth date. Students took approximately 30 minutes to complete the questionnaire in their normal classroom.

The semi-structured interview included a set of 12 standard questions as well as flexibility to probe or rephrase as necessary to ensure the students understood what was required. This method (Creswell 2005) is particularly suited to young interviewees, who may not share the same English vocabulary. Probing questions such as 'Tell me more' helped maximise the information from each student. The method allowed for positive affirmation from the interviewer, particularly when students became concerned about 'not knowing' answers. The interviewer clarified with the participants that she understood they might not have studied in school some of the ideas they would talk about, she was simply interested in what they 'think'. The interviewer is an experienced teacher with extensive experience conducting interviews with young children and as such was able to put the students at ease. The interview used stimulus pictures of cats and kittens to introduce ideas of shared features, probing initially for an understanding of basic familial inheritance, and then for any knowledge of genes and/or DNA as the mechanism of inheritance. The interview then moved to humans, what the students knew about DNA and/or genes and how they work in the body, and the sources from which they thought they had obtained this information. Finally, they were asked if they were aware of any additional uses of DNA outside the body, which is when they might link it to solving crime or paternity issues.

All interviews were audio recorded. The interviewer repeated answers and took notes on an interview record sheet. This made the participants feel that what they had to say was important (McKay 2006) and ensured the interviewer correctly understood what the interviewee was trying to say. The interview record sheet also enabled the researcher to note facial expressions and pauses and facilitated remembering each interview and locating specific statements of relevance to the research questions. Students' data (quantitative and qualitative) were transcribed under a pseudonym assigned to them to fit their cultural background. These pseudonyms are used in this article.

Methods of data analysis

Media questionnaire data

Media questionnaire data were used to assign different scores to each participant. These scores included a frequency score, a duration score, an annual score for each media type and a total media saturation score. The method used to calculate each of these scores is now explained. Media questionnaire data about the frequency of use of different media types were weighted so that scores represent yearly totals, for example, viewing TV daily was entered as 365 and reading a comic once a month as 12. This allowed the data to include rare events that would have been missed had the questionnaire asked about events on a weekly basis. Hence, each participant was given a frequency score for each media type. The length of time students said they usually spend each time they access the media types, or the duration scores, was entered as a score of one for one or less hours, a score of two for between one and two hours and so on. Another score called the annual score was calculated for each participant by multiplying their media frequency and duration scores for each media type. The annual scores were used to compare participants' average access to the different media types.

It was desirable to create a score that represented students' total media exposure during their active hours when they can freely choose to access different media. So, a novel method was devised to use the annual scores, participants stated rising and bed times and computation of the number of hours spent in school each year, to calculate individual media saturation scores as a percentage of their annual active non-school hours. This overall measure of media bombardment yielded scores ranging from as little as 8% to a high of 124%. Those students near and above scores of 100% must be routinely exposed to multiple media. The media saturation scores were divided by quartiles into four media usage groups designated low, medium, high and very high, with the latter group including the two scores above 100%. These scores were used to compare overall media saturation with students' genetics knowledge scores and misconceptions to look for patterns indicating any relationship between media saturation and genetics knowledge.

Genetics knowledge interview data

Interviews were scored out of 30, with scores for each question based on the number of ideas expressed (such as possible uses for DNA) to a maximum of three marks or two marks for a fully scientific answer, one mark for a partly scientific answer and zero for a non-scientific (or absent) answer. These scores provide a convenient, albeit crude representation of participating students' knowledge of genetics as a basis for comparison and for enabling patterns to emerge from the data. In addition, any misconceptions expressed in participants' answers were noted and tallied to provide a separate score. Some students did not express any misconceptions. This was occasionally because they had too little knowledge to have developed any but was more usually equated with fair to good knowledge scores. The maximum number of misconceptions stated by any individual student was six.

Once quantitative comparisons had been made with the various scores described above, the interview data were scrutinised again, and a search for examples that did and did not fit the patterns that emerged from the quantitative data analysis was conducted. Representative examples of both types of evidence are included in the findings.

Findings

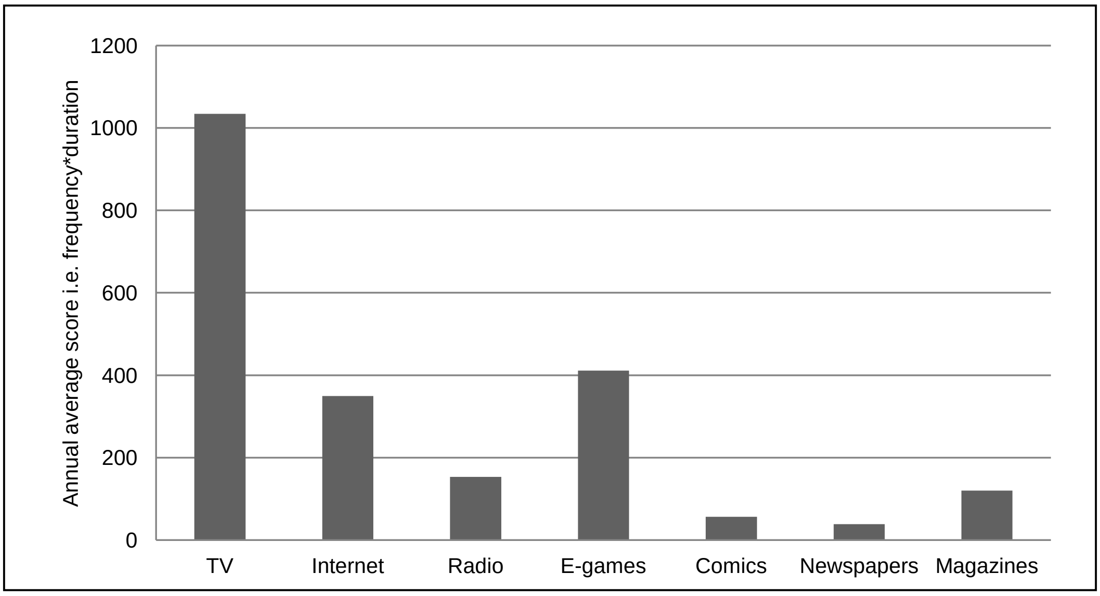
Research question 1 - what levels of exposure to the mass media do students report?

The questionnaire asked about eight types of mass media – TV, the Internet, radio, electronic (e-) games, comics, newspapers, magazines, and going to the movies. Despite there being a cinema in town, going to the movies proved to be a very rare event, so these data were omitted from individual consideration although included in the overall scores. The results showed that electronic media were accessed more often than print media. On a daily basis, 22 students watch TV, 9 access the Internet, 8 play e-games and 6 listen to the radio. All students watch TV at least once a week, and all but one access the Internet at home and play e-games on some occasions during a year. Magazines were the most popular of the print media with two students reading them daily and no students reporting never reading one. This contrasts with newspapers and comics where no students reported reading them daily, and 6 and 12 students, respectively, reported never reading them.

Duration of use data included students who spend 5 hours (or more) at a time with a chosen medium – six students with TV, three playing e-games and one self-confessed 'die-hard comics fan'. Of the electronic media, TV was accessed for the longest times, the Internet and e-games were typically accessed for up to 2 hours at a time, and radio typically for up to 1 hour. Of the print media, newspapers were only ever read for up to 1 hour, never more, whereas comics and magazines were typically read for up to 1 hour, but some students reported spending more time reading them.

As explained in the analysis section, combining frequency and duration scores yielded annual scores for each type of mass media, and the average of these for the 25 students are shown in Figure 1, giving an overall picture of participating students' media use.

Figure 1: Students' average access to each type of mass media



Research question 2 – what are participating students' levels of conceptual understanding in genetics?

All students expressed at least a rudimentary understanding of inheritance in terms of parents and offspring sharing physical similarities. All participants could select appropriate pairs of adult cats and kittens from the interview materials that might be related and support their choices. At the higher level of cognisance of the genetics mechanisms underlying inheritance, one Year 5 female student (Yr 5/F) lacked any idea of genetics and three others (two Yr 5/F and one Yr 7/F) had minimal understanding of genetics. Whilst other students may not have stated everything correctly, they indicated an appreciation that some particles (DNA and/or genes) are passed from parents to children, establishing relationship (usual answer) and similarity (less common answer).

In the interview, the majority of students (17 out of 25) spontaneously mentioned either genes or DNA as the answer to a question about what makes offspring resemble their parents, with two of them volunteering both DNA and genes. One of few noticeable age differences in this school was that the Year 5 students mentioned DNA, whereas the Year 6 and 7 students volunteered genes. Terms that had not been volunteered were then mentioned by the interviewer, during which time recognition of the term they had not volunteered was almost universally claimed. Five students claimed to have heard of chromosomes. Only 1 student (the Yr 5/F lacking any genetics knowledge) out of 25 claimed not to have heard of DNA, genes or chromosomes.

Interview scores out of 30 ranged from a low of 7 (the same Yr 5/F) to a high of 25 (a Yr 7/M) student with a mean of 17.84 and standard deviation of 4.56. Whilst there was a general progression in knowledge scores from Years 5 to 7, this was not absolute for each individual. For example, the second weakest knowledge score of 10/30 was attained by a Year 7 student. A few students were able to offer extra knowledge about cloning, the shape of DNA and speculate whether DNA would still be found in a dead person.

Research question 3 – what misconceptions do participating students have about genetics?

The data presented in Table 2 were abstracted from the interview data and previous research (Berthelsen 1999; Donovan and Venville 2004; Mills Shaw et al. 2008; Lestz 2008; Lewis and Kattman 2004; Lewis and Wood-Robinson 2000; Chattopadhyay and Mahajan 2004). The numbers refer to how many students in this school expressed each idea.

Whilst most of the ideas from the participants could be aligned with the key misconceptions found in the literature as shown, some novel ideas were expressed; for example, some students said: ‘people don’t have DNA’; ‘DNA is only related to blood tests for paternity’; ‘genes go into the air’; ‘genes like boy and girl’ and ‘genes/DNA are injected into kittens’. Several of these misconceptions were stated confidently and strongly, particularly the idea that DNA is only in the blood, likewise the concept that genes are the features. Only four students had no misconceptions, two students had four and one had six.

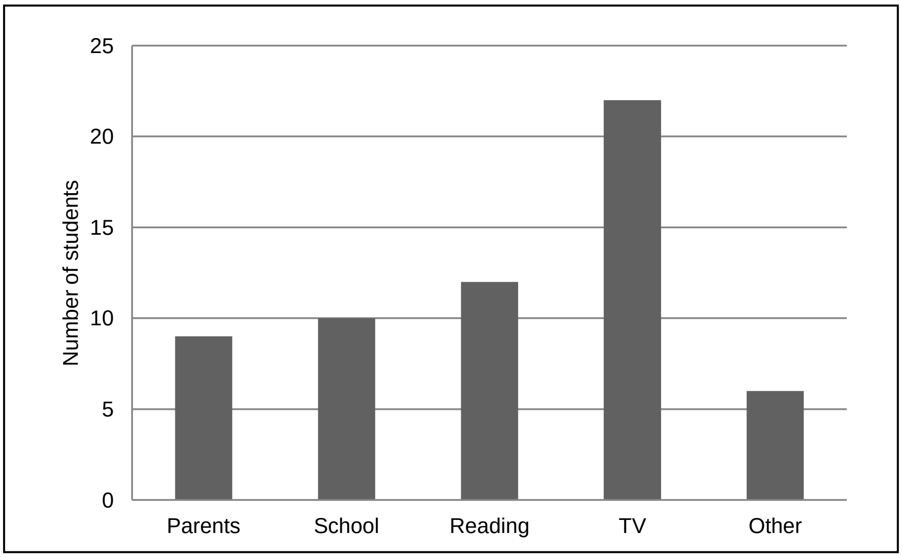
Table 2: Misconceptions from prior research and the school in this case study

Key known misconceptions	Misconceptions expressed by these students
Genes and DNA are two different things.	Genes are from parents but DNA (in blood) (1) has only a bit of your parents in it (1) Just had feeling genes and DNA are different (1)
Genes make you resemble your family, whereas DNA is what makes you unique and identifiable, primarily as a prime suspect.	Genes are part of you (your features) whereas DNA is uniqueness (4)
DNA does not have a biological function; it is just there to be shed at crime scenes.	DNA is linked to crime (1) DNA is used to find victims (1)
DNA is only found on the outside of the body (skin, hair, and fingerprints) and in the blood.	DNA is found in the blood (17), wrist (1), stomach (2), heart (1), fingerprints (3), circulates through the body (1), brain (2), skin (4), head (2), hair/fur (4), eyes (2), saliva (1) Genes are only in the liver and guts (1)
DNA can be found in some nonliving things (e.g. cars) but might not be in some living things such as plants, fungi, and microorganisms.	Plants lack DNA as it is only in something that moves by itself (1)
Genes are the characteristics or traits themselves (e.g. blue eyes is a gene).	Your features are your genes (i.e. deterministic belief that gene = trait) (3)/ DNA is behaviour (1)
Deterministic ideas that single genes exist 'for' particular traits (e.g. for fat legs or being a Viking). Also the idea that genes exist only to cause disease, especially in babies.	Genes cause diseases (1)
Girls get more DNA (or genes, chromosomes, genetic information) from their mothers and boys get more from their fathers.	Adults have more DNA than children (1) Son got all his DNA from his mother (1) Boys get more DNA from their fathers (1) We get unequal genes from Mum and Dad (1)

Research question 4 – from what source do participating students believe they have learned about genes and DNA?

During the interview, students were able to cite as many sources as they wished in response to a question about where they think they have learned about genes and DNA. Only one student had not heard of either genes or DNA and so could not cite any sources. Figure 2 indicates the number of students citing each source. TV was cited twice as often as any other source, and, half the time, it was mentioned first. Reading (books and Internet) was the second most common source. Ten students cited school as a source, yet none of the classroom teachers in this school recalled specifically mentioning genes or DNA in any lessons. Checking with the students, several said, 'No, in my old school'. As this school was new, the surveyed students had spent between 3 and 5 years in other primary schools before moving to this one, and, from their memories, genetics may have been mentioned as part of a human body unit in Year 4. The 'other' sources mentioned were grandmothers and medical personnel.

Figure 2: The reported sources of students' genetic information

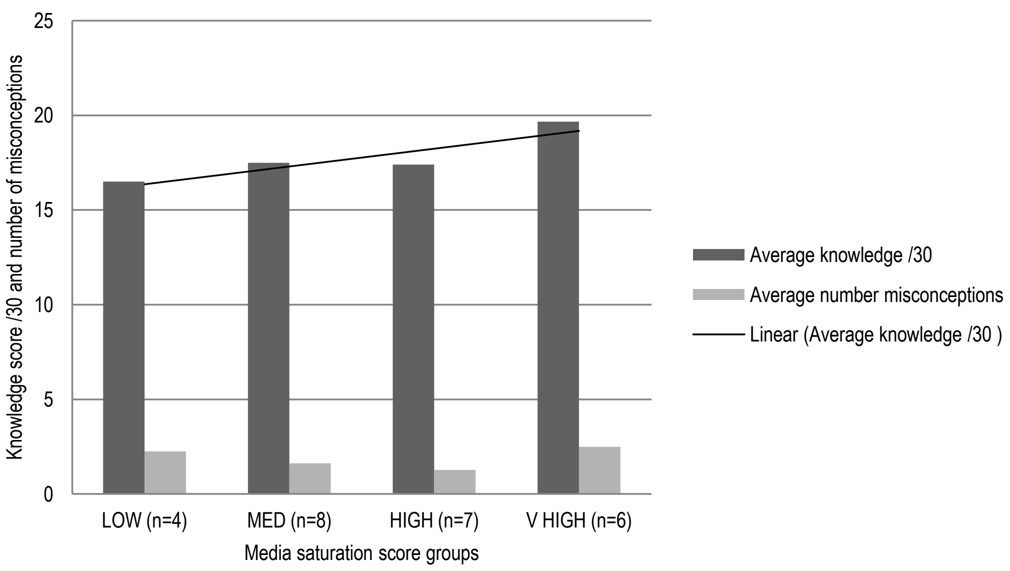


Research question 5 – what connections can be drawn between media use and participating students' conceptions?

General media use compared with genetics knowledge and misconceptions

Recalling that media saturation scores were divided into four groups of media usage, Figure 3 plots the participants' average knowledge about genetics and the average number of misconceptions found in each media usage group. Figure 3 shows that increasing media usage generally indicates increased knowledge, but whilst some media exposure shows a relationship with lower rates of misconceptions, this rose to a maximum with very high exposure to the media. These patterns suggest that students do gain knowledge from the media, but the knowledge is not always correctly incorporated into their conceptual frameworks.

Figure 3: Relating knowledge and misconceptions about genetics to overall exposure to the mass media



Specific media use – a focus on TV

Even though mentions of DNA and genes are ubiquitous in the mass media (Nelkin and Lindee 2004), the data show that students spend most time with TV and it is perceived by them as an important source of genetics information. Therefore, it is of special interest to elucidate connections between what students watch, particularly TV shows that mention genes and DNA, and their levels of knowledge and misconceptions about genes and DNA. Free-to-air TV is the main source for these students and despite the ongoing rollout of digital TV in Australia, the region of this school was still restricted to limited analogue channels at the time of the research. It was selected as the area lacks access to Australian Channel 9 TV, which screens several crime shows, including *CSI*, *Cold Case*, *Without a Trace* and *The Mentalist.* However, it does have access to Channel 10, which screens *NCIS* and *Law and Order*, and Channel 7, which screens *Criminal Minds*, *Bones* and *Find My Family*. Whilst a few students reported access to pay TV, those channels rarely screen crime shows.

One quarter of the students (all female, two Yr 5, one Yr 6 and three Yr 7) nominated one or two crime shows as favourites, *Bones* (2), *NCIS* (4) and *Criminal Minds* (2). Favourite characters included Booth (the FBI agent) and 'Bones' (the forensic scientist in *Bones*), Abby (the forensic scientist in *NCIS*) and Hotch (the team leader in *Criminal Minds*). However, the two Yr 5 students did not cite TV as a source of their genetics knowledge, nor mentioned that DNA might be used to solve crime. One of them claimed not to have heard of genes or DNA and the other had only heard of DNA. The older students all said TV was their primary source of information about genes and DNA and mentioned solving crime first as a possible use for DNA. Three of them spontaneously mentioned genes in terms of inheritance, the other had only heard of DNA. All students were also asked if they had ever watched specific crime shows, shows about families and science shows, and their answers to these questions provided useful background to compare with their knowledge and misconceptions.

Interrelating knowledge, sources and specific TV experiences

In 21 out of 23 examples where TV was mentioned as a source of information, solving crime or forensics was also mentioned as a possible external use for DNA. Of these, 10 students made a strong connection between crime shows and knowledge of DNA, mentioning TV and crime/forensics first or second, and 8 of them said they are regular watchers of *NCIS*, *Bones* and possibly other crime shows. Six students made a moderate connection (mentioning TV and crime/forensics second or third), and, of these, only one did not report watching any crime shows. The five students who made a weak connection, mentioning other sources and uses before TV and crime/forensics, watched none or minimal crime shows. Collectively, this creates a strong connection between TV as a source of information, specifically crime shows, and the notion that DNA is important for solving crimes.

Similarly, in 19 out of the 21 mentions of DNA being useful for resolving paternity, other familial relationships, or adoptions, TV was cited as a source of information. Most of these students watch *Find My Family* (13), and possibly *Can We Help?* (3), or *Who Do You Think You Are?* (1), whereas six do not watch or rarely watch such shows about families.

The data collectively point towards two main patterns: as media usage increases, particularly moderate exposure to TV shows about crime and genealogy, knowledge of genes and DNA increase, but heavy viewing may be counterproductive in terms of sound knowledge and misconceptions. Students who have moderate TV viewing levels also tended to cite TV as a source of their genetics knowledge and relate DNA to solving crime. The data set was searched for evidence that fits the patterns (presented in Table 3) and evidence that does not (presented in Table 4).

The five students presented in Table 3 each fit the general patterns in different ways. Two students, one from each of Year 5 and Year 7, show the counterproductive effects of heavy viewing and a reliance on TV. The other three profiles show the different effects of moderate viewing; in one case, it led to more misconceptions and, in the other two, it improved sound knowledge only.

The three students presented in Table 4 did not entirely fit the pattern. Saul's case, in which he stated that he does not pay much attention to TV, highlights the incapacity of this study to investigate the amount of invested mental effort (AIME; as described in Van Evra 2004, 39) involved in all these media interactions, which would have required independent observations of students as they interacted with the media. Diana was seemingly unaware that her viewing patterns may well have influenced her knowledge about genes and DNA. Carsten expressed some extremely novel ideas, which totalled to the maximum for any one student of six misconceptions. His media usage was also completely different from the rest of the students at this school.

Discussion

The patterns in the data presented in the findings indicate general support for the idea that the mass media is the likely source of at least some of the conceptions that the participating Year 5–7 Australian students hold about genes and DNA. There is also support for the findings of Springer and Kiel (1989) and Venville, Gribble, and Donovan (2005) that students have heard about DNA and genes before they reach high school. This implies that the issue of when genetics is first introduced in the curriculum should be a topic of serious consideration for educators, particularly curriculum designers. We strongly contend that accurate representations of these scientific concepts should be part of the upper primary school curriculum in Australia.

The results show that, for the 25 participating students, there was a wide range of exposure to the mass media, with some being minimally exposed, whilst others reported being supersaturated with media, routinely exposed to more than one at a time. This is consistent with the findings for American children as reported in Van Evra (2004, 215), in terms of hours spent (USA – 1000 hours per year; in this study [Figure 1], the average was 1038 hours per year), and routinely using multiple media. However, one in six American children watch TV for 5 hours a day (Van Evra 2004, xix); in this study, it is one in four (6 out of 25 participants). Electronic media clearly take precedence over print media.

Table 3: Confirming evidence for general patterns

Student	Source of information	TV shows watched	Interview score	Spontaneously mentioned	Knew body functions of genes and DNA	Are genes and DNA are similar or different	Misconceptions	Possible uses of DNA	Profile Summary
Tara Yr 5/F	TV	*Bones*, *Find My Family*, *Who Do You Think You Are*, and *NCIS* regularly, watches a lot of TV	12	Neither genes nor DNA	No idea	Guessed different	*'They find victims with DNA don't they'*	Solving crime Linking families	Heavy viewing counter-productive
Joey Yr 6/M	Reading, TV	*NCIS* and *Bones* sometimes	20	Genes	No, said DNA's function was *'so people can tell who did it'*	Knew they are similar	*'Girl and boy DNA may be injected into kittens' 'DNA is the same as blood' + 2 others*	Solving crime Chemical research	Moderate viewing improving knowledge but also increasing misconceptions
Hanja Yr 6/F	Gran, TV	*NCIS* is favourite show, *'Abby is awesome'* (forensic scientist in show), otherwise moderate TV viewing	24	Genes	Yes, to a point. *'DNA doesn't do much but it triggers what you look like'*	Knew they are similar	None	Solving crime Linking families	Moderate viewing improving knowledge without increasing misconceptions
Hailey Yr 7/F	TV, hospital	*NCIS* is favourite show, *'Abby is awesome'* , otherwise moderate TV viewing	20	Genes	Yes, to a point. *'Genes make people who they are'*	Knew they are similar	'*DNA is like blood'*	Solving crime Linking families	Moderate viewing improving knowledge without increasing misconceptions
Geordana Yr 7/F	TV	*Criminal Minds* and *NCIS* as favourite shows, also likes Abby, watches these regularly and a lot of TV overall	10	Neither genes nor DNA	No idea	Guessed different	*'DNA looks like normal blood, you can donate it'*	Donating it Solving crime	Heavy viewing counter-productive

Table 4: Evidence that does not fit the general patterns

Student	Source of information	TV shows watched	Interview score	Spontaneously mentioned	Knew body functions of genes and DNA	Are genes and DNA are similar or different	Misconceptions	Possible uses of DNA	Profile Summary
Saul Yr 7/M	Parents, old school, but definitely NOT TV as it is *'a waste of time'* then clarified *'I don't pay TV much attention'*	*Bones* and *NCIS* regularly, moderate TV viewing. *'I saw it on a doco on SBS'* for ideas about uses of DNA	20	Genes	A bit, knew they were microscopic and that *'Everyone has different DNA, can tell who you are'*	Different , *'DNA is about you, genes are looks you get from parents'*	*'DNA restricted to some parts like skin ripples ... genes are all over as you get them from your parents'*	Solving crime *Putting mammoth DNA into elephants'*, and *'Experiments in China putting human DNA into robots'*	Moderate viewing good score supports pattern, but denial of TV's role counters that
Diana Yr 6/F	Old school, reading, parents, NOT TV (only student to not mention TV yet related DNA to crime)	*NCIS* and *Law and Order,* moderate TV viewing	21	Genes	A bit, knew they were invisible, inside all cells, and that genes *'Make you a part of your family, people look alike'*	Knew they are similar, but *'Genes is a part of you, DNA is your uniqueness inside of you'*	Besides genes – similarity/ DNA – uniqueness, *'Genes are your features, like colour of eyes, hair colour, skin'* and linked DNA to blood type	DNA blood type - medical Solving crime	Moderate viewing good score supports pattern, but no recognition of TV's role counters that
Carsten Yr 5/M	TV only (only student who cited TV but did not also mention crime or forensics)	*Mythbusters.* TV set tuned to pay TV, *Discovery.* Very low TV viewing, spends 2x time with comics than with any of TV, the Internet, or e-games	16	DNA, *'I reckon they take DNA from their own body and then they put it onto the little kitten, that's still in their belly and then when it comes out, after a while it starts producing the same colour'* and *'Oh yes, genes like boy and girl'*	No. Answer to DNA location: *'It starts off as one person in the world, and then if it's a girl it might go to another girl, then it might multiply and multiply and multiply'*	Thought they were different	Six including DNA mostly from Dad *'my Dad's a boy, and I'm a boy, and my Mum's a girl. Just because I'm IN a girl, doesn't mean I'm going to BE a girl, cause my Mum could inhale ... something like ... skin cells? that flake off and that could come into the lungs, go through some sort of way ...*	Diagnosing disease Cloning Linking families	Impossible to characterise him with the general pattern as his ideas are so novel and his media usage so atypical of his peers

Historical analysis shows that this is the norm, with Shaw and Hamm (1997, 213) describing that each medium goes through a ‘King of the Hill’ period before being supplanted by the next new development. It is, therefore, feasible that, in the future, TV will be supplanted by the Internet.

When this study was mooted, it was not clear whether primary students would be watching the types of TV shows that include extensive reference to genetics-related topics. The findings clearly indicate that many (but not all) of the participating students were watching relevant TV shows on a regular basis. TV was perceived by the Year 5–7 participants as their predominant source of information about genetics. This finding was consistent with their overall exposure levels to TV, and generally with their reported data concerning TV shows they watch and consider as favourites. As noted in the findings, an individual may specifically deny the influence of TV even when they also report watching potential sources of information. This is consistent with the findings of Werner-Wilson, Fitzharris, and Morrissey (2004) who found that adolescents rarely voluntarily considered the media to be an influence on their sexuality, albeit a more sensitive topic than the source of their information about genes and DNA. Van Evra (2004, 10) refers to a ‘drip effect’ in which knowledge is picked up even when viewing TV primarily for entertainment. This may also help to explain the responses of students such as Saul and Diana in this study, whose interview data were not entirely consistent with the general patterns because they did not recognise that their knowledge might have come from TV.

All participating students had a basic understanding of inheritance, although four lacked sound knowledge of an underlying genetics mechanism. The word gene was more likely to be spontaneously mentioned than DNA, though the younger students mentioned DNA. Only 1 student out of 25 claimed not to have heard of DNA, genes or chromosomes. There was a general trend to older students knowing more about genes and DNA, but not for all individuals.

Some of the misconceptions found by Berthelsen (1999), Donovan and Venville (2004), Mills Shaw et al. (2008), Lestz (2008), Lewis and Kattman (2004), Lewis and Wood-Robinson (2000) and Chattopadhyay and Mahajan (2004) were also found to be held by participating students (Table 2). Some ideas are more incomplete than incorrect. For example, linking DNA to crime is not incorrect per se; it is just a very limited and skewed view of the function of DNA. This limited knowledge should be readily expandable with appropriate instruction. Some misconceptions expressed by the participants were entirely new to the interviewer, such as genes that go into the air or genes/DNA injected into kittens. Such idiosyncratic misconceptions could be more difficult to challenge successfully. In particular, Carsten’s ideas were creative and blended truth and fiction in a novel way. For example, he is right in saying, ‘Just because I’m IN a girl, doesn’t mean I’m going to BE a girl’ which is a subtlety most students do not even give consideration. However, his ideas that his mum could inhale some skin cells and that could be related to getting DNA are clearly unscientific and would be difficult to challenge in a classroom.

The widespread and strongly expressed belief that DNA is in the blood (and most students were emphatic that it is only in the blood) was puzzling. This has not been as widespread or firmly held belief in other groups interviewed in previous research (Donovan and Venville 2004) or during the larger study. Their classroom teachers did not recall that topic arising. Half of the students with this misconception also cited school as a source of information, but that could refer to their old school that they attended previously. Two-thirds of the students with this misconception cited TV, and nearly half of them cited parents. Some also mentioned news, books and medical personnel as sources, so it is difficult to draw firm conclusions.

Most students who reported TV as a source of information also expressed ideas about the possible use of DNA to solve crime, and nearly half of these students are regular watchers of crime shows. There was a similarly robust connection between TV as a source and ideas about DNA's possible use to resolve family relationships. This finding is in a region where less crime shows are screened than would be the case in many other Australian communities that have access to Channel 9. It is, therefore, likely that, in the larger study (or other countries where many such shows are screened), the evidence for these connections will be stronger. Older students who cite crime shows as favourites were more likely to connect DNA with solving crime and acknowledge TV as their main source of information, whereas younger students (Year 5s) do not and may not even realise that DNA and genes are mentioned on these shows. It could be that the Year 5s (aged 10 years) are more focussed on the action in the show, whereas Year 6 and 7 students pay more attention to the plot. This is in line with Rubin's (1985) finding that students aged nine mostly use TV for excitement, but that this decreases with increasing age. Evidence was not found that aligned with findings that children who name crime shows as favourites are more likely to identify with aggressive characters (Sprafkin and Gadow 1986). We found that the main characters identified with were the least aggressive ones, the forensic scientists in both *NCIS* and *Bones*, and the team leader in *Criminal Minds*. Students with more sources of information who watched moderate amounts of TV were more likely to mention genes, whereas those who watched a lot of TV, including many crime shows and considered TV their only source of information, were more likely to mention DNA. This could be linked to crime shows mentioning DNA more often than genes, as identification requires DNA testing.

The overall trends in the data indicate that more misconceptions are often found along with greater knowledge of genetics, and, again, this should prompt curriculum designers to include targeted, age-appropriate instruction on the basics of genes and DNA for these year levels. Some of the data indicate that moderate exposure, especially to shows that mention genetics more frequently, may be beneficial to knowledge development, whereas very high exposure is not. This data aligns with Fetler's findings (1984) that those children, especially of lower socio-economic status, who watch moderately (3 hours per day) show improved general achievement, and, with Cullingsford's (1984) findings that those who watch more TV pay less close attention and do not try to remember. Alternative explanations could be that very high exposure may decrease effective knowledge as the student is overwhelmed by too much information, or that students assimilate different ideas from different shows and are unable to construct them into a cohesive conceptual framework, resulting in misconceptions.

Limitations

Finding evidence both for and against the idea that watching crime shows is connected to specific understandings of genes and DNA indicates that no clear trend in this data set applies to every individual. This is not unexpected; indeed, it would be remarkable if a small data set showed simple correlations for such a complex topic. Unexplored in this study is the AIME (Van Evra 2004) made in watching TV shows by different students, and this could also result in enhanced knowledge (with higher AIME) or more misconceptions (with lower AIME).

Despite concerns raised in Van Evra (2004) about the reliability of self-reports, that is, that participants may skew their answers to what is deemed socially acceptable or normative, the propensity of these students to report heavy usage of mass media implies honesty. Estimates of the time spent with each medium are given credibility by the fact that, despite it being a very rare event for them, 21 students correctly estimated how long they would spend in a cinema watching a movie. The data are internally consistent with the results for frequency, in that students reported spending zero hours with the media type that they also reported never using. In addition, only two students apparently go to bed earlier than the shows they report watching, another indication of the reliability of the data.

Conclusion

The findings of this study show that students, even in a remote Australian community, are substantially exposed to the mass media, particularly electronic media, although there is a wide range of individual exposure. Despite their youth (ages 10–12), all but one student had heard of DNA/genes, although a range of knowledge levels about genetics was found. TV was self-reported as the major source of genetics information for participating students. Students expressed misconceptions mostly consistent with those reported in prior research; however, some novel misconceptions also were expressed. Despite this remote area’s reduced access to some televised crime shows, the data indicate that many students of this age watch whatever crime shows are available and hold beliefs that connect DNA to solving crime. A similar connection was found between watching TV shows that locate family members and beliefs that connect DNA and genes to resolving family relationships. These findings should stimulate discussion amongst Australian educators concerning the timing of introducing the vocabulary of DNA and genes in the national curriculum.

A general indication in the data is that increased exposure to the mass media is consistent with the greater genetics knowledge and more misconceptions. Results also indicate that a level of exposure exists beyond which the benefit of extra knowledge gives way to problematic loss of effective knowledge. The findings indicate that it would be worthwhile investigating in more depth the patterns in the larger study, and that these patterns could guide the design of a future study to specifically probe for a causal relationship between media exposure, knowledge and misconceptions in genetics.

Internationally, the relationship between the mass media and students’ conceptual understanding in science more generally and in genetics specifically is a neglected area of research, and yet misconceptions in genetics have been reported by researchers in UK (Lewis and Wood-Robinson 2000), USA (Mills Shaw et al. 2008), Europe (Lewis and

Kattman 2004) and Asia (Chattopadhyay and Mahajan 2004). It is hoped that this small study in Australia will ignite interest in researchers from other countries to explore the relationships between the mass media and genetics knowledge in different school and cultural contexts.

Finally, in their search for possible influences of the mass media upon students, the researchers are mindful of the following words from Carl Sagan.

> An extraterrestrial being, newly arrived on Earth--scrutinizing what we mainly present to our children in television, radio, movies, newspapers, magazines, the comics, and many books--might easily conclude that we are intent on teaching them murder, rape, cruelty, superstition, credulity, and consumerism. We keep at it, and through constant repetition, many of them finally get it. What kind of society could we create if, instead, we drummed into them science and the sense of hope? Carl Sagan 1996 p.39.

Whilst Sagan does not specify genetics, the ubiquity of DNA in the mass media as noted by Nelkin and Lindee (2004), and of misconceptions as noted in this article, suggests its inclusion as a matter of concern. Indeed, we might create a genetically literate society if all mass media treated the topics of genes and DNA with accuracy and teachers in schools followed this up with quality instruction at a sufficiently early age.

Notes

1. This freely accessible Australian Government website describes all Australian schools.

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